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LABAT-ANDERSON INCORPORATED

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

LABAT-ANDERSON INCORPORATED
8000 Westpark Drive, Suite 400
McLean, VA 22102

8. PERFORMING ORGANIZATION REPORT NUMBER

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9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

SERDP
901 North Stuart St. Suite 303
Arlington, VA 22203

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The SERDP efforts in FY91/92 emphasize assessing the state of the global atmospheric and ocean environments; the effectiveness of clean-up technologies for hazardous waste materials; the approach to minimize, treat, and dispose of hazardous waste; and methods for assessing hazards in existing and restored areas.

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STRATEGIC ENVIRONMENTAL RESEARCH & DEVELOPMENT PROGRAM (SERDP)

PHASE I AND PHASE II STRATEGIC INVESTMENT PLANS FY 1992

AND

INTERIM STATUS REPORT OF THE COUNCIL OCTOBER 1993

STRATEGIC ENVIRONMENTAL

RESEARCH & DEVELOPMENT

PROGRAM

(SERDP)

PHASE I

STRATEGIC INVESTMENT PLAN

FY 1992

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FOREWORD

The Strategic Environmental Research And Development Program (SERDP) is mandated in PL 101-510, November 5, 1990. SERDP addresses environmental matters of concern to the Department of Defense (DoD) and the Department of Energy (DOE). It is conducted as a tri-agency program with participation from the DoD, DOE and Environmental Protection Agency (EPA).

The SERDP identifies and develops technology to enhance capabilities to meet environmental obligations and to foster the exchange of scientific information and technologies among the participants and the private sector. The SERDP interacts with other environmental programs to identify and solve defense specific needs, extend applications of defense information to others, and build on existing science and technology to derive more useable and cost effective approaches for achieving reductions in environmental risks.

The SERDP projects are grouped under five topics -- Remote Sensing, Installation Restoration and Waste Management, Energy, Arctic Super Computer, and Other. The individual research projects were reviewed and selected by the SERDP Council to fit an overall funding target of $166 million. The approved projects are submitted on behalf of the SERDP Council with membership of: the Assistant Secretary of Defense, Production and Logistics; the Director of Defense Research and Engineering; the Vice Chairman of the Joint Chiefs of Staff; the Assistant Secretary of the Air Force, Space; the Assistant Secretary of Energy for Defense Programs; the Director of the DOE Office of Environmental Restoration and Waste Management; the Director of the DOE Office of Energy Research; and the Administrator of the EPA.

ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
DDR&E	Director, Defense Research and Engineering
DOE	Department of Energy
DoD	Department of Defense
IR	Installation Restoration
EPA	Environmental Protection Agency
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SERDP	Strategic Environmental Research and Development Program
SITE	Superfund Innovative Technology Evaluation
USGCRP	U.S. Global Change Research Program
WM	Waste Management

EXECUTIVE SUMMARY

The SERDP efforts in FY 91/92 emphasize assessing the state of the global atmospheric and ocean environments; the effectiveness of clean-up technologies for hazardous waste materials; the approaches to minimize, treat, and dispose of hazardous waste; and methods for assessing hazards in existing and restored sites.

Remote Sensing

Remote Sensing projects focus on characterizing the global environment, using advanced technologies for detection, analysis, and evaluation. Advanced surveillance methods are being applied to oceanographic and land characterization. Archival data (both classified and unclassified from national assets) and new data will contribute to environmental modeling and analysis. Data include the earth's radiation profile; tropospheric dynamics (chemistry, moisture, and temperature), and variation of trace constituents in the middle and upper atmosphere. Such data, which are critical to long-wave communications for military applications, also can be applied to predicting climatic changes.

Efforts are underway to demonstrate the use of acoustics to monitor ocean temperatures, using technologies developed by the Navy and DARPA. This will provide an important tool to indicate global temperature change and will provide the basis for decisions on implementing a long-term acoustic measurement program.

Installation Restoration and Waste Management

Site cleanup and waste management will be addressed by demonstrating the most promising technologies, evaluating their effectiveness, and providing specific selection and design criteria to potential users. Reduction in costs and time for restoration are being sought as well. Pollution prevention efforts focus on waste reduction, materials substitution, and process modifications. For remaining waste problems, such as hazardous organic and inorganic chemicals, efforts are directed toward characterization methods for soil and groundwater, as well as means to restore them to environmentally acceptable levels.

Energy

Demonstrations on alternative sources of energy and energy conservation means are directed at potential savings of $200 million a year in military installations.

Arctic Supercomputer

A grant will be executed under which the University of Alaska shall serve as the owner, operator and administrator of the Arctic Region Supercomputing Center (ARSC). The ARSC shall serve the supercomputing needs of the SERDP and other DoD and national needs. The DoD will be entitled to 25 percent of the available CPU time at no charge.

Other

The development of a reliable, cost-effective environmental management strategy for DoD sites is being pursued through the development of a scientifically defensible exposure-hazard-risk assessment methodology.

EPA will prepare eight manuals of practice on innovative technologies with the potential for permanent treatment of contaminated waste sites at DoD installations.

Programs addressing DoD long term environmental R&D needs will be identified based upon user requirements and advancing technological capabilities for the development of a long term R&D strategy to guide the DoD into the next century.

Funding Summary $(000)

Remote Sensing		64,000
Installation Restoration and Waste Management		61,500
Energy		8,800
Supercomputer		25,000
Other		6,700
	TOTAL	$166,000

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REMOTE SENSING		
Technology Projects	**Pg.**	**Funds $(000)**
Definition and demonstration of Remote Sensing Capability to Contribute to Environmental Understanding and Support for Environmental Issues	3	8,600
Joint DoD and DOE Atmospheric Remote Sensing and Assessment Program for Global Climate Change	6	35,400
Acoustic Monitoring of Global Ocean Climate	10	20,000

REMOTE SENSING TOTAL = $64,000

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Definition and Demonstration of Remote Sensing Capability to Contribute to Environmental Understanding and Support for Environmental Issues

OBJECTIVE:

Document and provide the capabilities of sensors, data, and processes in support of environmental issues. Identify system and process enhancements in support of DoD, other Federal Agencies and the civil research communities' environmental requirements.

APPROACH:

Current understanding of the capabilities of remote sensing as they apply to national security issues infer that these same capabilities could provide data that would be of use to environmental research and regulation. The proposal leads to the investigation of this proposition and the documentation of the applicable data that responds to the requirements for environmental information. Further, this effort will examine enhancements that would improve the access to the data, systems, and the processes.

The effort will use utility studies to document the capabilities of remote sensing to contribute to specific issues or programs and provide access to data that is relevant to environmental programs. Research and development will be conducted in areas that the utility studies indicate as high return; opportunities for the transfer of technology to other Federal Agencies, Civil Agencies, and the Global Change Research Community will be examined as a separate category of this effort.

Initially, the emphasis of this program will be to perform and analyze case studies, and to identify valid and specific applications for environmental sensing applications. As these case studies mature and produce validated applications, emphasis will shift to applications planning and implementation, together with supporting research and development. It is expected that successful case studies will follow a two-year validation cycle, and then transition into implementation.

During FY 1992, study research will begin in four major areas. These are:

Oceanographic Characterization

Assess applications related to monitoring polar ice caps and glaciers to determine feasibility of (1) mapping the ice edge, leads, and ridges within the sea ice pack, (2) estimating ice thickness, (3) monitoring the advance and retreat of glaciers, and (4) studying the thermal mixing in coastal regions of the sea.

Land Characterization

Assess applications related to monitoring and managing environmental change and site characterization to support (1) landscape characterization, (2) identification of vegetation stress, (3) detection and tracking of pollution and (4) determination of other parameters which indicate environmental change.

Data Access

The effort will include a survey of existing archives of classified data products and related database capabilities. The current archive and access procedures will be evaluated with respect to preserving the archive and allowing access by a wider community of users. In addition, alternatives to existing procedures and policies which provide enhanced services will be investigated.

Technology Research

Presently the best, and for some cloud characteristics the only, global cloud analysis is the RTNEPH residing at the U.S Air Force Global Weather Center. RTNEPH became operational in 1983 and is based on mid-1970's technology. Current technology will be identified and applied to enhance RTNEPH capabilities and increase its access to the national and international climate modeling community.

BENEFITS:

The inherent capability to provide non-intrusive data collection over significantly large areas can enhance the ability of the environmental community to make accurate predictions of global change and environmental regulation monitoring. The extent of pollution may be promptly and accurately detected to speed assessment and policy formulation and the application of remediation technologies, as well as the development of more effective technologies.

The requirements for global cloud analysis and detailed representative cloud analysis and detailed representative cloud data have increased over the past decade. The need for increased access to cloud data and enhanced cloud analysis is critical and the components for developing it are available.

PARTNERS AND RELATED ACTIVITIES:

It is anticipated that this effort will lead to cooperation among DoD, DOE, NOAA, DoA, USGS, EPA, and other Federal Agencies. This effort promotes the establishment of a well defined process for accessing data and services that will enhance the mission accomplishment of Federal Agencies and improve the data available to the research community.

MILESTONES: FY

	FY
• Field verification and ground truth establishment	92
• Demonstration of remote sensing observation strategies and systems	92
• Improved access to existing databases and facilities Study and develop mechanisms for transferring unclassified and recently declassified information to other governmental agencies and to nongovernmental organizations involved in global environmental change research.	93
• Application of remote sensing capabilities to environmental change research	92-93
• Determine modifications or additions to existing and planned systems to enhance capability to support environmental change analysis	92-93

FUNDING ($M):

	FY92
Current	.25
SERDP	8.60

RESEARCH ACTIVITY: Defense Support Project Office, Room 4C1052 The Pentagon, Washington, D.C. 20310, Norman S. Spencer, (703) 614-3277.

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Joint DoD and DOE Atmospheric Remote Sensing and Assessment Program for Global Climate Change

OBJECTIVE:

To investigate, understand and assess global atmospheric change by augmenting DoD spacebased sensors for monitoring the middle and upper atmosphere and developing proposed DOE sensors for observing the troposphere. Global change of the earth's atmosphere is a critical environmental problem. Investigating, understanding and predicting climate change is the focus of a national effort. The measurements of these changes required to develop predictive models are obtained from existing and planned programs including NASA's EOS program. Unfortunately, the tempo of the development of satellite measurement capabilities is not keeping pace with the problem. This proposed SERDP project is to accelerate ongoing research and inject existing DoD/DOE sensor/satellite technology into the most critical gaps in the national program.

APPROACH:

Over the past ten years the Naval Research Laboratory (NRL) has made substantial investment and commitment to remote sensing of the middle and upper atmosphere. This includes the theoretical modeling effort needed to interpret the observations. This project will augment and focus specifically on the atmospheric global change problem and the development of an enhanced predictive capability. Our existing monitoring projects include a series of experiments to measure most of the important constituents of the middle and upper mesosphere, both neutral and ionized components. The middle and upper atmosphere observing program by the addition of a UV imager for upper atmosphere remote sensing and a mid-latitude solar occultation stratospheric ozone monitor complement our currently planned polar measurements.

DOE is pursuing a program in Atmospheric Radiation Measurement (ARM) which is a major component to the United States Global Change Research Program developed by the Committee on Earth and Environmental Sciences (CEES). One of the goals of this program is to address climate change processes from the surface to the troposphere. This program consists of ground based and airborne instruments measuring lower atmospheric energy balance and cloud properties at several sites selected for their climatological importance. The aim of the ARM program is to gather data of necessary and unprecedented accuracy on cloud-climate feedback and earth radiation budget at the identified climatological sites.

The DOE portion of this project will be a complementary space segment to collect data on atmospheric processes at the ARM sites. This will assist the ARM objective to enhance the speed and reliability of improving climate predictability. Three sensors are proposed for this task: a Radiometric Imager, a Multispectral Pushbroom Imaging Radiometer and a Lidar for measuring cloud height. These instruments are candidates for flights on both air

breathing and satellite platforms as available under the DoD's Space Test Program.

These instruments for the lower atmosphere will investigate the earth's radiation budget and associated processes. This will give important information on the global tropospheric temperature and will allow an investigation of the poorly understood process of cloud feedback on the global warming problem.

In order to support this extensive measurement effort, a state-of-the-art data base system will be developed that will allow the data to be readily accessed and displayed. The data from the tropospheric sensors will be fully integrated with the ARM data system. The third leg of the proposed research effort is a theoretical modeling program. NRL currently has an operational 1-dimensional photochemical model of the middle atmosphere, and a 2-dimensional photochemical/dynamical model now under testing. We will augment this portion of the program by the addition of a 3-dimensional model which includes coupling between the lower, middle, and upper atmosphere and accurate orography to describe momentum transport and deposition in the upper atmosphere. DOE's ARM project has a similar modeling program for the troposphere. We plan to use the models in a synergistic fashion with the measurements. That is, the measurement will be used to test various model parameterizations and, thereby, improve these parameterizations. In turn, the models will be used to interpret the measurements. Through this combined program we hope to produce a large enhancement in the knowledge of the processes responsible for atmospheric global change and, thereby, an improved predictive capability.

Additional supercomputing capacity for this proposal and for the entire SERDP shall be provided from an existing facility which is geographically situated to provide the required staff necessary to ensure uninterupted service. This facility will also be able to dedicate 13,000 central processing unit (CPU) hours of operational activity for an indefinite number of years in order to guarantee uninterupted availability of the system. The system would have the capability of providing data management/data visualization technology, access to geographic information systems (GIS) methodology, as well as high speed computing capacity.

BENEFITS:

This project should not be viewed as acting in isolation from other existing national programs to study global climate change currently in place at NASA and other CEES agencies. We have always worked very closely with these organizations and our work would be viewed as complementary. In particular, our remote sensing program is aimed predominantly at the 1995-2000 period. There is presently a great national need for space-based atmospheric measurements during this time period. The NASA Upper Atmospheric Research Satellite (UARS) was launched in September 1991 and has a total lifetime of 5-7 years. The next large-scale NASA space-based remote sensing program is the Earth Observing Satellite (EOS). EOS is not expected to be launched until at least 1998. Thus, there gap before the start-up of the NASA program which could be filled by our proposed program. Further, it is possible that a

continuation of our program would complement the capabilities and global coverage of the large platform being considered by NASA. This would then allow an uninterrupted series of measurements of the sun/earth system for two decades which is required in order to sort out and understand the many complex and tangled issues involved in global change. In addition, our proposed program would put the DoD/DOE as equal partners with NASA and NOAA at the forefront of this vitally important research effort.

This project directly addresses the chemistry, dynamics, and variations of trace constituents in the middle and upper atmosphere. This plays a central role in several areas of DoD interest. Middle atmosphere: Longwave (VLF/ELF) communication systems, used for early warning and strategic communications, are dependent on the electron densities in the "C" and "D" regions of the ionosphere which are, in turn, controlled by the abundance of neutral middle atmospheric constituents. Among the most important of these are NO, H_2O, and O_3, all of which will be measured on a global basis by sensors proposed in this project. Also the natural variability of several trace constituents of the middle atmosphere, including CO_2, H_2O, and O_3, is now the limiting factor in the performance of infrared space surveillance systems. Finally, neutral atmosphere density variations are critical factors which are needed for improved vehicle reentry and trajectory calculations. Upper Atmosphere: The upper atmosphere component of our project focuses on obtaining a suite of measurements which allows the characterization of the neutral atmosphere and the ionosphere above 100 km. The relevance for DoD of this region of the atmosphere is very similar to that listed above for the middle atmosphere. The "E" and "F" regions of the ionosphere are critically important in DoD communication and surveillance systems. In addition, neutral density variations, and their response to solar variations, are a necessary ingredient for calculating satellite drag.

PARTNERS AND RELATED ACTIVITIES:

This project is a joint cooperative program between DoD and DOE, and should lead to further cooperation among NASA, NOAA, USGS, EPA, other Federal agencies, the University community and industry. The proposed program will be integrated into the CEES USGCRP via coordination with the Working Group on Global Change and its Task Groups. Opportunities for further collaborative efforts will be sought for optimum application of the federal research resources.

MILESTONES:

Observations of O_3, H_2O, ClO 2D dynamical/photochemical model. Initiate fabrication of troposphere sensor. Acquire sensor hardware for fabrication.	FY92
Issue RFP; award contract for supercomputer processing capacity.	FY92
Spaceflights for three stratospheric and ionospheric sensors.	FY93
Preliminary model evaluation using O_3, NO, etc. Complete fabrication of tropospheric sensors. 3D dynamical/photochemical model incorporating gravity wave orography and climatology. Spaceflight for three atmospheric sensors.	FY94
Initial verification of atmospheric models. Spaceflight for tropospheric sensors (in cooperation with the CEES small satellite activity).	FY95
Spaceflights for five atmospheric sensors. Continued verification of 3D models.	FY96
Collection and analysis of data model. Confirmation of global climate change.	FY97-98

FUNDING: ($M)

	FY92	FY93	FY94	FY95	FY96	FY97	FY98	TOTAL
NRL	11.9	8.3	7.1	6.0	3.1	1.5	1.5	36.4
DOE	23.5	12.5	9.5	10.6	10.7	10.7	5.0	82.5

RESEARCH ACTIVITY: Kenneth J. Johnston, Code 4200, NRL, (202) 767-2351
Peter W. Lunn, Code ER-74, DOE, (301) 903-4819

OK

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Acoustic Monitoring of Global Ocean Climate

OBJECTIVE:

Conduct a "proof of concept" program to demonstrate the feasibility of conducting a long-term global program which will measure the temperature of the ocean and incorporate those measurements in appropriate climate models to quantify global climate variability. A demonstration system will be deployed in an ocean basin to gain experience for implementing a global system. At the conclusion of this effort it will be possible to make an informed decision on the establishment of a long-term (10-year) Acoustic Measurement Program to monitor climate variability.

BACKGROUND:

Since ocean temperature is a key indicator of global temperature change, an accurate measurement of the temperature of the ocean would provide conclusive evidence of the existence and amplitude of global change. In the January, 1991, Heard Island Feasibility Test (HIFT) acoustic signals centered at 57 Hz were transmitted from the R/V Cory Chouest at a location near Heard Island (54 S, 74 E in the southern Indian Ocean) to 14 receiver stations manned by 9 nations. The paths between this source and the 14 receivers spanned all the world's oceans and extended to as long as 15,000 km. This test had two objectives: (1) Determine whether acoustic signals could be transmitted over global distances with modulated sources, and (2) Determine whether propagation times could be measured with the accuracy required for monitoring global warming. The HIFT was a success and demonstrated that acoustic signals of moderate intensity can be transmitted and received over global paths with sufficient signal to noise ratios to measure propagation time. In fact, signals at receivers in the Atlantic and Indian Oceans were received with signal-to-noise sometimes exceeding 40 dB. The arrival structure proved to be exceptionally phase stable and persisted for 20 minutes to an hour, depending upon receiver location. Thus, the propagation times along the paths could easily be measured to the needed precision over time scales of this order. However, the HIFT data indicate that the multipath/mode structure of the arrivals is significantly more complicated than initially predicted. Interpreting these propagation-time measurements to infer average velocity along the paths is complicated by the effect of internal waves and mesoscale eddies. During the Heard Island Feasibility Test, marine mammal activity was monitored.

APPROACH:

HIFT demonstrated the capability to measure propagation times over the very long paths needed to average out spatial variability. The next step is a more extended experiment to collect the data necessary to design the full-scale long-term program to measure global temperature changes. The major issues involve source and receiver design, resolution of the multipath/modal structure of the arrivals, and an understanding and quantification of the effects of natural variability of ocean temperatures. While HIFT demonstrated

that available sources have adequate power, their reliability must be improved for long-term deployment. The initial approach is to deploy a moored, possibly directional, source at a 1 Km depth operating near 70 Hz with a 20 Hz bandwidth. HIFT demonstrated that source levels can probably be reduced by 10-15 dB, and this plus the deep mooring will significantly reduce the potential for adverse effects on marine mammals. To resolve the structure of the arrivals, both vertical and horizontal arrays are required. The plan is to use NAVFACs for the horizontal arrays and to deploy vertical arrays near some of the NAVFACs. While the simplest array configuration necessary to make the required measurements should be used for the long-term program, data from these more complex configurations is needed initially to understand the signals and their natural variability. For understanding the effects of seasonal and other natural variability, a deployment of at least 12 months is necessary. A modeling effort including both long-range acoustic propagation models and models for the ocean climate will be part of the program.

This effort will result in a demonstration program which will encompass sources and receiver arrays in the Atlantic and Pacific Ocean basins as well as the Arctic. The program will develop robust and affordable receiving stations, some of which might be vertical, horizontal, or three-dimensional arrays. Interconnection and networking of all data from the collection sites is a key element of the program.

The program is designed to develop the information needed for a FY94 decision on whether to proceed with the long-term program. This requires the collection, detailed analysis, and interpretation of large volumes of complex data in a short period of time. To accomplish this, the program will exploit advanced data collection, organization, and manipulation technologies developed by other DARPA programs. Also to be included is the initiation of arrangements for the transition of this "proof of concept" program from the development to the operational stages for an eventual long-term observation program.

This program will include academic performers, industrial partners, and government laboratories. Key academic performers will include: Scripps Institution of Oceanography, Applied Physics Laboratory, MIT, and the University of Michigan. Overall technical direction will be provided by Professor Walter Munk, the originator of this idea.

<u>BENEFITS</u>:

This program will benefit the Office of the Oceanographer of the Navy by helping to resolve the issue of how to obtain and implement useful, affordable spatial maps to internal ocean variability. The emerging science of global acoustics will allow broad-ocean exploration and relates strongly to current Navy efforts, including the need for tomographic basin-scale mapping of ocean variability as an input to Navy ocean modeling and prediction systems. The results of monitoring of marine mammals around the experiments in this program will provide valuable scientific data for use in planning the long-term experiment.

PARTNERS AND RELATED ACTIVITIES:

This program combines several technical initiatives into a streamlined program involving multi-service, multi-agency, and multilateral cooperation and coordination. DARPA will provide overall program direction and will coordinate with military and civilian organizations, foreign governmental, and research institutions. Coordination within DoD will be with the Navy and the Air Force, and within the U.S. Government with NOAA, NASA, DOE, and NSF.

At least nine foreign countries have expressed an interest in participation in the program outlined above. They are Australia, Canada, France, India, Japan, New Zealand, Norway, South Africa, and the USSR.

MILESTONES:

Modify existing source	CY 92
Initiate source development	CY 92
Design and develop receivers	CY 93
Develop network design	CY 93
Initiate development of data collection systems	CY 92
Evaluate existing data	CY 92
Deploy source and receivers	CY 93
Establish data collection systems	CY 93
Collect data	CY 93
Monitor marine-mammal activity during experiments	CY 93
Evaluate results	CY 94
Decision point	CY 94

FUNDING ($M):

	FY92	FY93	FY94	FY95	TOTAL
SERDP/6.1	20.0	0.00	18.95	17.0	56.0
SERDP/6.2					
SERDP	20.0	0.00	18.95	17.0	56.0

FUNDING DISTRIBUTION: To be determined.

RESEARCH ACTIVITY: Defense Advanced Research Projects Agency, Arlington, VA, Dr. Ralph Alewine, 703-696-2246.

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INSTALLATION RESTORATION AND WASTE MANAGEMENT		
Technology Projects	**Pg.**	**Funding $(000)**
Basic Installation Restoration & Development 1) in Waste Management, and 2) for Environmental Restoration (DOE)		
Basic Research and Development in Waste Management	20	4,200
Basic Research and Development in Environmental Restoration; New Insights on Natural Subsurface Heterogeneity	25	3,800
Plutonium and Uranium Metal Forming Technologies (DOE)	31	6,100
DOE Total		**$14,100**
Develop and Demonstrate Effective Site Restoration, Pollution Prevention, and Pollution Control Technologies Applicable to Defense-Related Operations (EPA)	34	**$9,700**
Installation Restoration and Waste Management Technology Development and Demonstration (DOD)	38	
Composting of Explosives Contaminated Soil	40	500
Nondestructive Decontamination of Chemical Agent Contaminated Structures	42	3,500
Nondestructive Decontamination of Explosive/Propellant Contaminated Process Equipment	44	300
Clean Energy/Conservation	46	2,700
Unexploded Ordnance (UXO) Detection	48	1,100
Biomonitoring	50	1,200
HAZMIN Technology for Tactical Vehicle Maintenance Operations	51	1,000
Analytical Methods/Instrumentation Development	53	1,200
Biomagnetic Separation Processes	55	150
Use of Biomaterials for the Removal of Hazardous Chemicals for Contaminated Soils	58	100
Waste Stream Cleanup by Enzymatic Oxidation in Non-Aqueous Solvents	60	115
Enzymatic Decomposition of Energetic Material	62	290

Installation Restoration and Waste Management Technology Development and Demonstration (DOD)		
Technology Projects	**Pg.**	**Funding $(000)**
Extraction & Recycling of LOVA Propellants Using Supercritical Fluids	65	150
Fate & Transport in Seasonally Frozen Soil and Discontinuous Permafrost	67	130
Identification and Testing of Non-Ozone Depleting Halon Agents	68	125
Selective Recovery and Re-Use of Heavy Metals in Waste Streams with Bioengineered Polymers	70	290
Effects of Sorption, Survival and Activity on Biological Treatment of Explosives and Organic Compounds	72	250
In Situ Treatment of JP-5 and Fuel Oil Vapors in Unsaturated Soils	75	600
Underground Fuel Steam/Vac Removed	77	150
Small Arms Range Remediation	78	400
Heaped Soil Bioreactor	80	50
Underground Fuel Pump and Treat Demonstration	81	250
Coastal Area Capping Technology	82	200
PCB Decontamination Using Base Catalyzed Decomposition Processes (BCDP)	83	200
Fuel Contaminated Groundwater Treatment Using Photochemical Oxidation	84	45
Petroleum Contaminated Groundwater Treatment by Biological Processes	85	320
Slurry Bioreactors for HW Remediation	87	450
Penetrometer Transition/Validation	89	600
Penetrometer Chemical Sensors	91	430
Integrated Marine Risk Assessment Methodologies	94	570
Encapsulated or Immobilized Enzymes and Bacteria for Remediation of Fuel Spills	96	300
Buried Ordnance Detection	98	400

Installation Restoration and Waste Management Technology Development and Demonstration (DOD)		
Technology Projects	**Pg.**	**Funding $(000)**
Mineralization of TNT to Innocuous End Products by Microorganisms	100	350
Chemical/Photochemical Processes for TNT/RDX Treatment	102	300
Biodegradation of Nitrate Esters	104	350
Characterization of Decomposition of Nitrate Esters	105	100
Range PEP Decontamination	106	150
Mobile Utility Support Equipment (MUSE) NOx Emissions Reduction	108	400
Leak Detection System for Large Underground Fuel Storage Tanks and Pipelines	109	500
Oxygen Breathing Apparatus Canister Disposal	111	145
Lithium Battery Disposal as Reactive Hazardous Waste	112	100
Propellant Ingredient Extraction	114	100
Solventless Processing of Magnesium Teflon Viton (MTV) and Magnesium-Teflon Hytemp (MTH) Pyrotechnics	115	150
Explosive Waste as Fuel	116	100
Propellant Recycling	117	200
Ultraviolet Destruction of Nitrate Esters	118	300
Pyrotechnic Dye Incinerator	119	250
Bilge Waste Treatment System	120	400
Hazardous Material Shelflife Extension	122	200
Hazardous Material Control Technologies	123	400
Ship Paint Reformulation	125	500
Ship Abrasive Blast Recycling	126	560
Treatment of Waste Sodium Nitrite Solutions	128	120
Ship Surface Preparation and Paint Removal Technologies	129	250
Organic Protective Coatings and Application Technology	132	500

Installation Restoration and Waste Management Technology Development and Demonstration (DOD)		
Technology Projects	**Pg.**	**Funding $(000)**
Non-Chlorinated Strippers and Low VOC Solvents	134	300
Aircraft Depainting Technology	136	500
Electroplating Waste Reduction	138	340
A/C Maintenance Chrome Replacement	140	200
IVD Aluminum	142	50
Aluminum-Manganese Electroplating from a Molten Salt Bath	143	100
HALON Replacement	145	120
Reduced Solids Precipitation Technology	146	100
In-Situ Contaminant Mobility Reduction Using Surfactants	147	105
Zero Discharge Plan Development	149	500
Enhanced Anaerobic Degradation of Fuels in Groundwater	151	200
Enhanced Redox Biodegradation	154	400
Spray Casting as an Alternative for Electroplating	156	650
Abiotic Degradation of Groundwater Contaminants	158	160
Demonstration of Low Temperature Ashing for PMB Waste Treatment	160	350
Toxicology	162	1,000
Validation of Aphron Oxygen Enrichment of Subsurface	163	300
Halon 1301 Aviation System Replacement	166	300
Halon 1301 Facility Total Flood Agent Replacement Program	168	400
Non-Toxic Surface Preparations for Aluminum and Titanium Structural Alloys	169	100
Crossflow Air Stripping with Catalytic Oxidation	171	650
Minimal Treatment Option for JP-4 Contaminated Soil	173	250
Alternative Solvents/Technologies for Paint Stripping	175	300
Improved Hydrocarbon Remediation Monitoring	177	400
Prototype VOC Monitor, Phase 3	179	203
Pulsed Hydraulic Flushing	180	300

Installation Restoration and Waste Management Technology Development and Demonstration (DOD)		
Technology Projects	**Pg.**	**Funding $(000)**
Treatment of Chlorinated Organics with Aboveground Bioreactors	182	400
Pilot-Scale Validation of Liquid Phase Oxidation	184	300
Groundwater Transport in Model Systems	186	80
Biodegradation Technology for Hazardous Waste Treatment	188	200
Chemical Characterization of Carbonaceous Materials from Aquifers	190	150
Advanced Microporous Membranes	192	120
Spill Remediation Guide	194	150
Demonstration of Soil Washing at Beale AFB with EPA (Site Program)	195	587
Emerging Technologies with EPA Support of Site Program	197	600
Bioventing Demonstration with EPA	198	175
Metabolic Pathways Control	199	210
Anaerobic Dechlorination of C1 and C2 Organics	200	50
Catalytic Destruction of Chlorinated Organics	201	90
Fiber Optic Monitoring System Development	202	190
Systems Integration for Monitoring Technologies	203	250
Improved Methods for Monitoring Fuel Biodegradation	204	400
Biodegradation of Energetic Materials	205	130
Enhanced Biodegradation through Soil Venting	206	450
Packed Tower Air Stripping	207	150
In-Situ Biodegradation of Jet Fuels	209	200
Electrolytic Reduction of Chlorinated Hydrocarbon Compounds	211	50
DoD Total		**$37,700**

Installation Restoration and Waste Management Total = $61,500

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Basic Research and Development 1) in Waste Management, and 2) for Environmental Restoration

OBJECTIVE:

To address basic research needs in support of the development of advanced technologies for the management and disposal of radioactive, hazardous, and mixed wastes, and to strengthen the scientific base of understanding of complex subsurface mechanisms involved in contaminant stability and mobility in natural surroundings.

APPROACH:

By laying out the bounding scientific principles and phenomena and by providing a framework for systematic technology development, technology advancement in the areas will be accelerated. Initial needs are for reproducible, reliable sampling methodology and suitable descriptive data collection, analysis, and modeling procedures.

BENEFITS:

Advanced analytical methods, improved instrumentation for in-situ characterization of stored wastes, better understanding of waste form materials needs, and improved chemical pretreatment and separations processes would result from the research proposed. The results of this research will contribute to establishing the technical feasibility of innovative technologies and to implementing basic and applied R&D activities directly associated with the application of technologies for waste treatment to meet compliance requirements and protect the environment.

Understanding the fundamental subsurface mechanisms that control contaminant stability and mobility will contribute directly to cost-effective and environmentally safe remediation of mixed wastes at DOE and DoD facilities. Environmental restoration at complex field sites is limited by the heterogeneous nature of subsurface environmental systems and existing remote technologies to observe them and collect data to characterize them. Effective remediation requires an understanding of such heterogeneous systems. While many new biological, physical, and chemical remediation technologies have recently been tested at the laboratory scale, field scale remediation is limited by uncertainty in the distribution of contaminants and transport processes, which in turn are controlled by natural, largely unpredictable, heterogeneity.

MILESTONES (Summary of one year program milestones):

- Refine the technical program plan using workshops in conjunction with DoD and EPA.
- Complete development of initial set of analytical procedures for semivolatile organic compounds important to EPA and state agencies.
- Develop strategies for characterization of organic constituents relevant to chemical reactions occurring in waste.
- Complete assessment of the scientific limitations of current low radioactive level waste forms and identify advanced candidates for further development.
- Complete identification of candidate methods and determine scientific feasibility for selective extraction of technetium and cesium from low level waste streams.
- Initiate exploratory characterization of subsoil heterogeneity at a select DOE site.
- Conduct small and intermediate scale simulations of selected model heterogeneity systems.
- Evaluate and initiate testing of promising sub-soil measurement and characterization methods.
- Evaluate and begin testing of geostatistical methodology using available data sets.

FUNDING ($M):

The Waste Management and Environmental Restoration budget (in $ million) is:

	FY92	FY93	FY94	FY95	FY96
Waste Management:	4.2	10.5	10.5	11.0	11.5
Env. Restoration:	3.8	6.2	10.0	10.0	10.0
Total:	8.0	16.7	20.5	21.0	21.5

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Basic Research and Development 1) in Waste Management, and 2) for Environmental Restoration:

Part 1: Basic Research and Development in Waste Management

OBJECTIVE:

To address basic research needs in support of the development of advanced technologies for the management and disposal of radioactive, hazardous, and mixed wastes that are generated through DOE and DoD activities.

APPROACH:

In general, technology development activities for the areas of physical and chemical characterization of wastes, pretreatment of wastes, final waste disposal form, interim confinement, retrieval, permanent waste confinement, waste transmutation, and waste minimization are patchy and fragmented. Thus, by laying out the bounding scientific principles and phenomena and by providing a framework for systematic technology development, technology advancement in the areas will be accelerated. Near term efforts will focus on the following high priority areas:

Advanced Analytical Methods and Equipment Development. Improved knowledge of waste chemistry is urgently needed to help guide waste management strategy formulation and technology development activities. Many DOE wastes are highly complex in nature and have not been encountered in non-DOE applications. Thus, methods are virtually nonexistent for certain waste components while others need to be up-dated. Therefore, modern equipment will be obtained and methods will be developed, in order to have improved methods for characterizing complex wastes.

During FY92, advanced analytical equipment will be procured and modified as necessary to address the complex wastes. Research efforts will be initiated to improve analytical methods for organic and inorganic species in defense wastes currently involved in regulatory compliance with the EPA and state agencies. This activity will also address the characterization of organic, inorganic and organometallic species relevant to the chemical reactions which occur in the most active DOE wastes.

In-situ Characterization. Detection and characterization of waste constituents is one of the key issues in planning and conducting a waste management program. Use of sensors that can characterize and quantify wastes and process streams in-situ offer substantial savings in time and cost compared with conventional laboratory analysis of samples. In some cases, such as high level wastes, characterization costs are extremely high because of the hostile environment and sampling difficulties. Remote sensors for chemical characterization generally rely on two fundamental mechanisms for detecting and quantifying chemical species: selective chemical reactions and spectroscopy of a wide range of particles and electromagnetic phenomena. Neutron spectroscopy may be particularly important for some high level waste

constituents. The focus of this task is the study of the underlying mechanisms that lead to the development and improvement of these sensors. Research will be performed to develop and optimize transduction methods (such as fiber optics and piezoelectrics) that transform the chemical information into optical or electronic signals that can be remotely monitored.

During FY92, an in-depth and definitive assessment of the feasibility and limitations of in-situ waste chemical characterization will be performed. This assessment will address methods, equipment, sensitivity, selectivity, etc. to develop a list of candidate analyses and associated in-situ analytical procedures and equipment for subsequent development.

Advanced Waste Form Materials. We need to conduct a comprehensive evaluation of the feasibility and limitations of low-level waste forms capable of effectively immobilizing certain difficult-to-contain constituents in the presence of complicating components. These advanced alternatives have the potential to reduce the need for costly pretreatment operations. The effort will include engineering studies on known candidates as well as bench scale studies to synthesize and characterize new and modified waste forms.

Efforts during FY92 will focus on identification and testing of alternate waste forms that can immobilize low-level waste containing high levels of nitrate and nitrite. The performance of current grout formulations is limited because the leach behavior of soluble species, such as selenium-79, iodine-129, technetium-99, cesium, nitrate and nitrite. Consequentially, external barriers are often required to isolate soluble species in grout from the ground water.

Waste Pretreatment and Separations. Many DOE and DoD wastes are characterized by large volumes and relatively low concentrations of hazardous and radioactive components. There are strong economic incentives to partition these wastes into a large fraction that can be properly disposed of in inexpensive, near-surface facilities and a much smaller fraction immobilized for final disposal in a deep geologic repository. Such partitioning requires the development of advanced separation, dissolution, and chemical conversion technologies. This effort will focus on the assessment, development, and testing of emerging technologies in this area. Advanced separation methods will include the synthesis and development of selective sequestering agents in the areas of solvent extraction, facilitated membrane transport, and adsorption by solid sorbants. Waste dissolution will focus on chemical (acidic, basic, and neutral aqueous washes) and electrochemical dissolution. Waste dissolution will also study selective leaching of target components. Chemical conversion technologies will include the destruction/separation of nitrates, nitrites, phosphates, and organics using thermal and catalytic destruction, electrochemical oxidation and reduction, and supercritical oxidation.

During FY92 this activity will emphasize the assessment, identification, and initial experimentation on advanced separations processes for the selective extraction of Cs and the anionic form of technetium. These species are typically dilute and in the presence of competing ions and are difficult to extract without the creation of significant secondary waste streams. This

effort is expected to provide a basis for selective extraction of other hazardous metal anions and cations.

BENEFITS:

The results obtained will provide the mechanistic underpinning that is necessary to establish the technical feasibility of innovative technologies and to guide R&D efforts that are directly associated with application of the technologies. The results will accelerate the availability of data and methods needed to define waste treatment technology requirements, advance the development of cost and time-saving in-situ characterization technologies, define the potential of advanced low-level waste forms, and advance the development of cost-saving waste pretreatment and separation technologies.

PARTNERS AND RELATED ACTIVITIES:

This work will be a joint effort involving the DOE-ER laboratories.

MILESTONES:

One-Year Program Milestones:

- Complete development of initial set of analytical procedures for semivolatile organics important to EPA and state agencies, and complete development of strategies for characterization of organic constituents relevant to chemical reactions occurring in waste.

- Complete assessment of the scientific limitations of current low level waste forms and identify advanced candidates for further development.

- Complete identification of candidate methods and determine scientific feasibility for selective extraction of technetium and cesium from low level waste streams.

- Complete procedures for polar reactive constituents in wastes.

Multi-year Program Milestones:

FY92

- Develop an initial set of analytical methods needed for complex wastes.

- Assess needs for modern analytical equipment for waste management.

- Complete a comprehensive assessment of the potential of in-situ characterization of complex wastes. Select the high priority sensor targets and most promising concepts and identify the key phenomena limiting their potential performance.

- Assess currently known candidates for advanced low-level waste forms.

- Initiate research on cement-based formulations for improved retention of mobile anions and cations.

- Identify and experimentally screen technologies in advanced separations, waste dissolution, and chemical conversions to establish the advanced baseline technologies.

FY93

- Complete purchase of modern analytical equipment for use in waste management.

- Initiate development of new analytical methods and equipment for use in waste management.

- Initiate research on polymer and ceramic-based advanced waste form formulations.

- Initiate development of promising in-situ sensors identified in FY92.

- Assess and initiate studies of new methods for advanced low-level waste forms.

- Initiate development of promising pretreatment and separation technologies identified in FY92 using synthetic waste.

FY94

- Conduct laboratory-scale studies of selected pretreatment and separation technologies on actual waste samples.

- Conduct laboratory evaluation of prototype sensors on actual waste materials in realistic operating environments. Identify and characterize key phenomena limiting performance in these applications.

- Initiate research to provide basis for long-term stability projections of selected advanced waste forms.

FY95

- Complete development of laboratory prototypes and documentation of the performance of new pretreatment and separation methods.
- Complete development, documentation, and reporting of all research on advanced waste forms.
- Continue development, characterization, and performance documentation of advanced sensors.

FUNDING ($M):

1-YEAR BUDGET:

Task	FY92
a. Analytical Methods	2.0
b. Characterization	0.5
c. Materials Waste	0.9
d. Separations	0.8
Total	4.2

MULTI-YEAR BUDGET:

Task	FY92	FY93	FY94	FY95	FY96
a. Analytical Methods	2.0	3.5	3.0	2.5	2.5
b. Characterization	0.5	1.5	2.0	2.0	2.5
c. Waste Form Materials	0.9	2.5	2.5	3.0	3.0
d. Separations	0.8	3.0	3.0	3.5	3.5
SERDP	4.2	10.5	10.5	11.0	11.5

RESEARCH ACTIVITY: R.S. Marianelli, Department of Energy, Office of Energy Research ER-14, Washington, DC 20585, (301) 353-5804

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Basic Research and Development 1) in Waste Management, and 2) for Environmental Restoration:

Part 2: Basic Research and Development for Environmental Restoration: New Insights on Natural Subsurface Heterogeneity

OBJECTIVE:

Understanding of the fundamental subsurface properties that control contaminant stability and mobility is necessary to ensure cost-effective and environmentally safe remediation of mixed wastes at DOE and DoD facilities. Environmental restoration at complex field sites is limited by the heterogeneous nature of subsurface environmental systems and by existing remote observational technologies to extrapolate natural heterogeneities among subsurface boreholes. Remediation success or failure is often controlled by natural geologic, chemical, and microbial variations in the subsurface. While many new biological, physical, and chemical remediation technologies have recently been tested at the laboratory-scale, field-scale remediation is limited by uncertainty in the distribution of natural, largely unpredictable, heterogeneities.

The objectives of this program are (1) to apply selected characterization techniques and methodologies to evaluate emerging in-situ remediation methods in the presence of natural hydrogeologic, geochemical, and microbiological heterogeneities in the subsurface, and (2) to evaluate emerging remediation concepts in terms of the unpredictable complications that natural heterogeneity introduces to the cleanup process.

APPROACH:

Predicting mixed-waste contaminant behavior and evaluating new remediation concepts will require comprehensive, fundamental knowledge on chemical, microbial, and physical processes which operate simultaneously and at different scales in subsurface environments. Fundamental knowledge of these processes and their interactions at different scales must be derived from laboratory, intermediate-scale, and field studies. The extraordinary heterogeneity in properties in the subsurface require new geostatistical and computer concepts and methods to improve predictions. Advanced numerical concepts are also needed because contaminant behavior under ambient and remediation conditions must be predicted in three dimensions principally on the basis of observations from a limited number of holes and wells.

Because current field characterization techniques are inadequate to define the heterogeneous distribution of biological, physical, and chemical properties (and therefore remediation) at contaminated sites, new technologies and methodologies are critically needed. These methodologies include (1) new visualization and computer processing technologies to assist in extrapolating natural changes between sites, and (2) advanced geostatistical and in-situ characterization technologies.

Computer Simulation and Visualization of Spatial Variability. Computer--based numerical experiments can now be conducted which incorporate new understanding of multiple, complex, nonlinear natural processes, and in conjunction with actual field-scale measurements, enable researchers and environmental engineers to conduct experiments of subsurface phenomena. It is also possible to visualize in real time how the variability in geological and geochemical properties controls the transport and fate of contaminants with and without the injection of heat, liquids, gases, chemicals or biological nutrients associated with engineered remediation. Such numerical experiments can be conducted with synthetic data sets. A comprehensive field and intermediate scale research program will allow incorporation of data on real properties and processes. This will in turn provide greater understanding of the relationships between spatial scales; enable the testing of new theories and mathematical approaches for determining the scale and frequency of required sampling; and support the design and simulation of remediation alternatives prior to costly field-scale actions.

Geostatistical Predictive Methods. Advances in statistical theory and practice are needed for use in designing subsurface sampling efforts, interpreting and scaling laboratory and intermediate-scale observations to the field, and optimizing the design and evaluation of remedial actions. New approaches are needed to statistically select sampling areas based on evolving, but limited, knowledge of subsurface properties, linking sampling schemes to new models incorporating this information. New (Bayesian-like) approaches would be developed for incorporating scientific knowledge about subsurface properties (in the form of probabilities) into sampling plans and models. Uniquely instrumented nationwide sites (and/or intermediate scale research facilities for controlled studies) would provide the basis for derivation, development, and validation of these methods over ranges of heterogeneous complexity.

Successful remediation at DOE and DoD sites requires an ability to predict where natural physical (geohydrologic), chemical (groundwater chemistry), and microbiological heterogeneities in the field. Field instrumentation to characterize the nature of such heterogeneities is lacking. Developing and applying (e.g.) new or innovative geostatistical methods, or computer visualization approaches that allow local measurement to be extrapolated to larger areas, demand concomitant progress in new measurement and characterization technologies, some of which could be tested at lower cost in the laboratory than in the field. DOE's Subsurface Environmental Research Facility (SERF) at Batelle Pacific NW Laboratory (and selected universities) will be used to enhance the development of selected new instruments in the presence of simulated, controlled heterogeneities.

New, unique data sets will be generated as field and/or intermediate scale studies are completed, and as new instruments are tested. These new data sets can serve other DOE or DOD needs, e.g. validation of new models. After intensively characterized (with respect to natural heterogeneities) field sites have met basic research needs, some will be useful to test new remediation concepts or untried remediation technologies. An example is a DOE concept for benign manipulation of the redox chemistry of an aquifer in-situ.

Using such sites, risks such as unexplained technological failures or unanticipated costs could be reduced.

This project will identify field research sites in humid and arid environments where field experiments can be conducted. Sites at DOE facilities would become national user facilities focused on DOE's and DoD's unique mixed waste problems, and would be available for interagency cooperative research.

The field approach envisioned here would be complemented by appropriate laboratory research, with emphasis on studying natural heterogeneity (as a contributor or impediment to remediation) under controlled conditions, and by computational studies that extrapolate physical, chemical, and microbiological properties that change on scales of meters to kilometers.

BENEFITS:

This task will enable the DOE to investigate natural heterogeneities as a controlling and complicating remediation problem. Initiation of this task will contribute to restoration decisions that are made in a scientifically defensible fashion which can lead to enhanced environmental protection and cost savings. Other agencies will also benefit, such as the EPA and the U.S. Geological Survey (USGS).

Preliminary planning for investigations of natural heterogeneity that has been conducted since 1987 will ensure that substantial progress can be made by DOE and its partners in one year. For example, a published DOE basic research plan in support of environmental restoration details some of the needs that are referenced in this proposal. Additionally, field experimental sites have been identified near the 300 Area of Hanford and at Melton Branch, Oak Ridge National Laboratory, for studying natural physical, chemical, and microbiological heterogeneity. Planning was refined at a workshop in July 1991; based on workshops in 1987 and 1990, experimental (intermediate scale) flow cells were designed that include controlled natural physical heterogeneity, e.g. layering and dispersed high or low permeability zones. Some university collaborators have already been identified. Federal agencies who participated in workshops between 1987 and 1990 contributed to flow cell planning and design.

PARTNERS AND RELATED ACTIVITIES:

DOE national laboratories will work cooperatively on this task. Laboratories that are presently supporting the Subsurface Science Program are already in a position to operate effectively in initiating this work. The integrated effort among weapons and multipurpose laboratories that now exists will focus on a major, emerging issue: heterogeneity in natural subsurface systems. Some initial thinking has already been done to plan the necessary research program. We will continue to improve liaison with DoD, EPA, USGS, and other federal organizations concerned with contaminant transport, as initiated through the CEES Subcommittee on Water Resources, a federal interagency group.

The Subcommittee on Water Resources is an important interagency forum for scientific information exchange and research planning. Building on the Subcommittee's activities, DOE proposes two planning workshops that will draw on the skills of the USGS, EPA, and DoD to assist in defining a one-year and five-year program for evaluation of natural subsurface heterogeneity. The U.S. Geological Survey, for example, has special expertise in evaluation of physical heterogeneity. EPA's (Oklahoma) Laboratory and Office of Research and Development might contribute to studies of subsurface microbial (spatial) heterogeneity.

MILESTONES:

One-Year Program Milestones. One-year funding of $3.8M will result in substantial new insights of natural (field) heterogeneities, information which the National Academy of Sciences identified in a recent report as being very limited. Field and intermediate experiments would be run in parallel. Principal one-year research results would be: (1) analysis of microbial spatial and vertical heterogeneity within subsoils of the Melton Branch watershed (to complement DOE-sponsored determinations of natural physical heterogeneity, now in progress); subsoil zones are impacted by mixed waste disposal and the role of microbial communities in mobility or stability of contaminants is poorly known; and, (2) determinations of physical, chemical, and microbial heterogeneity to form a research data base within an experimental site at Hanford; such natural heterogeneities together influence contaminant migration and successful remediation. An additional milestone is (3) completion of several exploratory intermediate scale experiments to determine the effects of microbial heterogeneity under various flow regimes, to be completed by a consortia of national labs and universities.

These milestones can be met within a one-year program by intensive subsurface sampling; analysis of microbial vertical and spatial heterogeneity (where data are nearly non-existent) will be accelerated by drawing on already tested, integrated drilling, tracer, and aseptic sample processing protocols developed by DOE's Subsurface Science Program. At reduced budget levels, important progress will be made but the scope of the research will be scaled back. At 90% of proposed funding ($4.5M), the subsoil investigations planned for Melton Branch (ORNL) will be scaled back from a subwatershed scale to approximately a 100-square-meter area. At 80% funding ($4.0M), the breadth of natural laboratory and university participation in subsoil and intermediate scale investigations and the number of controlled intermediate scale experiments in microbial heterogeneity will be reduced. At 50% funding ($3.5M), field studies will be eliminated in favor of soil block (field simulation) or core experiments on the order of cubic meters and laboratory experiments will be increased. At all funding levels, determinations of natural field heterogeneities at the manipulative experimental site at Hanford will be retained providing that proportional increases in complementary support from the Hanford Site (DOE/RL) can be obtained.

Five Year Program Milestones. A five-year program would facilitate a broader, more systematic analysis of natural heterogeneity and physical--microbial-chemical interactions than a one year effort. For example, additional interagency research and coordination workshops would be held to

refine research plans and to enhance interagency coordination; and, a progressive series of long-term, controlled intermediate scale experiments to complement field experiments would be achieved. Intermediate and field experiments would be run sequentially, with results from controlled intermediate scale experiments being used to improve the design of manipulative field experiments. An outline of operating milestones are:

<u>MILESTONES</u>:	<u>FY</u>
• Refine technical program plan using workshop(s). Initiate exploratory characterization of ORNL/PNL field sites. Complete test study of microbial heterogeneity - subsoil site. Complete test study of heterogeneity - Hanford site. Conduct intermediate scale simulations of selected heterogeneities. Evaluate/begin testing - promising measurement/characterization methods. Evaluate/begin testing geostatistical/visualization methods using available data sets.	92
• Begin long-term intermediate scale experiments - broaden methods testing. Begin long-term field experiments/ broaden site(s) characterization. Select in-situ remediation test cases for study - interagency input. Compare field characterization/intermediate scale experimental results. Conduct First Interagency SERDP Workshop - Methods Technology Transfer.	93
• All field sites operational - complete new instrument evaluation. Integrate intermediate scale and field data sets/observation. Conduct Second Interagency SERDP Workshop-Influence of Heterogeneities on Remediation (interim observations using test cases).	94
• Complete field studies - assemble data sets on natural heterogeneities. Consolidate research results - Refine theory of scaling up using new field data sets. Apply theoretical results to remediation test case. Conduct Third Interagency SERDP Workshop - Transfer New Data Sets (initial conclusions on remediation test cases).	95
• Organize International SERDP Meeting - New Insights in Natural Heterogeneities (transfer scientific/remediation experience).	96

REFERENCES:

1. Subsurface Science Program Overview. 1991. U.S. Department of Energy, Office of Health and Environmental Research, 47 pp.

2. Basic Research For Environmental Restoration. 1990. U.S. Department of Energy, Office of Energy Research, 156 pp.

3. Review of Intermediate-Scale Experiments for Subsurface Microbiology and Chemistry, 1987, Workshop Proceedings, 50 pp. Subsurface Science Program, Office of Health and Environmental Research.

FUNDING ($M):

	FY92	FY93	FY94	FY95	FY96	TOTAL FY92-96
SERDP	3.8	6.2	10.0	10.0	10.0	40.0

Note: FY95 and FY96 funding reflects high cost field studies.

RESEARCH ACTIVITY: F.J. Wobber, Department of Energy, Office of Energy Research ER-74, Washington, DC 20585, (301) 353-5549

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Plutonium and Uranium Metal Forming Technologies

OBJECTIVE:

Uranium and plutonium metals are used extensively in the fabrication of nuclear weapons. Depleted uranium is used in conventional weapons such as kinetic energy penetrators and liners for shaped charges. Due to the toxic and radioactive nature of these materials, hazardous waste generation from current metal machining, wrought and casting processes for plutonium and uranium parts are dominant contributors to DOE waste streams. The objective of this research is the development of new forming technologies such as precision or near-net-shape die casting to significantly reduce or eliminate waste generation in the manufacture of these weapon parts. Die casting to final shape with no subsequent machining can, if successful, result in a greater than 90% reduction in scrap with an accompanying reduction in contaminated waste and personnel radiation exposure.

APPROACH:

The project will develop precision or near-net shape die casting for producing plutonium and uranium components with little or no need for machining. This effort will demonstrate feasibility and reproducibility starting with simple shapes and ultimately demonstrate the technology for complex free-form part contours with a goal of reproducing the tolerances currently achieved through precision machining for weapon parts. If machining is required, it will be done with dry machining techniques developed as part of a separately funded initiative to minimize waste generated in existing wet machining processes involving contaminated machining oils and cleaning solvents. Parts will be produced for engineering and nuclear and conventional weapons tests, and design of a prototype die-caster will be completed for technology transfer to a DOE production facility. Analytical modeling will be key to achieving precise control of the casting process (for plutonium there is a unique property of net expansion during the solidification/cooling process). An experimental effort to improve the understanding of liquid metal, and in the case of plutonium epsilon phase properties, will support the modeling effort. This coupled, iterative experimental and analytical approach will provide an efficient and rapid development of the die casting technology. The program will involve extensive hardware design and development including incorporation of liquid actinide resistant die molds and crucibles, production die designs and automation. Recent successful experiments focussed on initial feasibility indicate significant potential for this technology.

BENEFITS:

Plutonium utilization efficiency for current casting, wrought and machining processes for pit production is about 30 to 40%. These processes result in significant amounts of machining chips contaminated with machining oils, contaminated gloves, wipes, solvents, etc. Each of these streams requires treatment: in the case of the plutonium machining, chips separation of machining fluids prior to recycle and, for the other streams, plutonium

extraction to the extent economically feasible as well as disposal of nontreatable wastes. The waste treatment and extraction processes generate their own waste streams which again must be treated or packaged as storable wastes where appropriate. Many of these steps are performed in a manpower intensive environment resulting in high levels of worker exposure to radiation. Current uranium part manufacturing techniques result in similar concerns although the radiation hazard and therefore personnel exposure levels are significantly reduced.

Near-net-shape casting combined with dry machining will significantly reduce machining chips and wastes resulting from wet machining processes. In the limit, precision casting could, if feasible, eliminate machining and associated waste streams entirely, resulting in a greater than 90% reduction in scrap with accompanying reduction in contaminated waste and radiation exposure. This will result in large cost savings from residue recovery, waste treatment, waste shipping, and long-term storage activities.

<u>PARTNERS AND RELATED ACTIVITIES</u>:

This work will be carried out by LANL, LLNL, EG&G Rocky Flats and Oak Ridge Y-12 as a joint, coordinated effort.

<u>MILESTONES</u>:	<u>FY</u>
• Develop casting parameters and demonstrate simple shape (flat plate) casting building on earlier casting research. Develop computer model based analytical capability to define optimum casting parameters and explore process sensitivity to parameters. Develop flow sheets for potential incorporation of processes into reconfigured production complex. Evaluate warhead performance sensitivities to anticipated part tolerances in the complementary RD&T funded warhead design program.	92
• Demonstrate spherical shape castings and continue analytical development and associated normalization experiments. Begin development of flow sheet technology elements with emphasis on automation of processes.	93
• Demonstrate casting of free-form, complex shape actual weapon parts. Begin design of prototype die-caster for production operations. Begin engineering tests (funded through RD&T) of completed cast parts. Begin RD&T funded design of a nuclear test using cast parts.	94
• Complete technological transfer of die-caster to production plants and demonstrate performance in a production environment. Execute RD&T funded proof-of-principle nuclear test using die-cast parts.	95

- Evaluate RD&T funded nuclear test and institute process changes and long-term aging studies. 96

FUNDING ($M):

	FY92	FY93	FY94	FY95	FY96	TOTAL
SERDP	6.1	8.00	9.00	9.00	10.5	42.6

RESEARCH ACTIVITY:

DO NOT NEED

Dr. William B. Shuler
Deputy Associate Director, Advanced Programs
Lawrence Livermore Laboratory
Box 808
Livermore, Ca. 94550
Telephone: FTS: 543 0800, Commercial: (415) 423 0800
Telefax: FTS: 543 5029, Commercial: (415) 423 5029

Mr. Howard R. Canter
Deputy Assistant Secretary for the Complex Reconfiguration
Department of Energy, Washington, D.C.
Telephone: FTS: 896 2700, Commercial: (202) 586-2700
Telefax: FTS: 896 2180

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Develop and Demonstrate Effective Site Restoration, Pollution Prevention, and Pollution Control Technologies Applicable to Defense-Related Operations

OBJECTIVE:

The objective of this proposal is to apply Environmental Protection Agency (EPA) developed technology and knowledge to remediate contaminated sites, to reduce pollutant emissions from existing defense-related operations, and to prevent future pollution where possible. An integrated program is proposed which includes both demonstrating state-of-the-art emission reduction technologies to determine their applicability to defense-related operations, and the development and demonstration of innovative remediation and pollution control approaches which will assist in achieving future defense-related environmental compliance requirements. The third primary objective of this proposal is to reduce the effluents generated at defense-related operations through pollution prevention.

APPROACH:

Several EPA research laboratories have extensive experience in developing and demonstrating environmental restoration techniques and pollution prevention/control approaches. The research proposed will utilize the expertise, and in some cases facilities, located in these laboratories to develop, evaluate, and apply remediation and emission reduction approaches to defense-related operations. In most cases, EPA will utilize defense-related facilities to demonstrate the innovative technologies. The proposal will be divided into three components: site restoration, pollution control, and pollution prevention. The following is a summary of the major activities planned in each of these areas:

A. Site Restoration

- Develop, evaluate, and test in-situ chemical and biological remediation methods and technologies for restoration of soils, sediments, lagoon bottoms, and groundwater contaminated by the manufacture and disposal of munitions: chlorinated solvents; metals, metalloids, and organometallics.

- Develop innovative technologies for managing wastes and the resulting contaminated water associated with defense-related site remediation activities.

- Develop expert systems and handbooks to provide guidance on site investigation and remediation techniques.

B. Pollution Control

- Demonstrate innovative techniques to reduce metals, air toxics, and sulfur oxides emitted from combustion sources (boilers and waste incinerators) at defense-related facilities.

- Evaluate and demonstrate technologies and approaches to address the problem of treating contaminated surface and ground water at defense-related facilities.

- Evaluate the use of air biofilters to degrade volatile organic compounds emitted from fuel spills and degreasing operations; and evaluate accelerated waste decomposition and methane recovery through landfill leachate recirculation.

C. Pollution Prevention

- Evaluate, demonstrate, and develop substitute compounds and alternative processes which will reduce or eliminate air pollutants from defense-related operations including mission critical uses. Efforts will be focused on reduction of air toxics, tropospheric ozone precursors, and compounds which cause stratospheric ozone depletion.

- Evaluate and test the use of supercritical carbon dioxide (process change) as an alternative to using solvents in cleaning and degreasing operations. This process change will reduce the generation of hazardous wastes and volatile organic compounds (VOCs) from these operations.

- Promote source reduction by developing training materials to assist engineers at defense-related facilities in carrying out waste minimization assessments and demonstrating selected pollution prevention approaches at these facilities, particularly metal finishing and electronics operations.

<u>BENEFITS</u>:

The broad program described above will provide the opportunity for EPA, the Department of Defense (DoD), and the Department of Energy (DOE) to share expertise as they work cooperatively to resolve existing and future environmental problems at defense-related installations. Many of the long-standing problems at these installations can be resolved cost-effectively by adopting technology familiar to EPA and its research staff. The adaptation of existing technologies to specific defense-related application will also save DoD and/or DOE engineers time and resources which would have otherwise been devoted to identifying and possibly demonstrating similar clean-up technologies. Also, emerging technologies and remediation approaches developed by EPA offer the potential of lower cost and/or higher clean-up effectiveness. Finally, many of the results from this research could be utilized by the private sector to deal with similar problems.

PARTNERS AND RELATED ACTIVITIES:

Many of the specific activities proposed under this project have been discussed in detail with the specific DoD and DOE installations, all of whom have expressed interest in collaborating in the research proposed. The following are examples of potential partners: U.S. Army: Corps of Engineers, Waterways Experimental Station (part of DoD's Environmental Restoration Program), USATHAMA; U.S. Air Force: Tyndall Air Force Base, FL; U.S. Navy: Naval Ordnance Environmental Support Office, Indian Head, MD; DoD Office for Chemical Demilitarizing (Destroy Army's Chemical Stockpiles); DoD CFC Advisory Committee; DOE: Oak Ridge National Laboratory; Battelle Pacific Northwest Laboratory.

MILESTONES:

Site Restoration

- Chemical remediation process technologies for restoration of defense-related sites contaminated with TNT, solvents, and metals.

- Laboratory treatability studies to determine the feasibility of using selected innovative biological treatment methods for the restoration of soils and ground water contaminated with RDX, TNT, and HMX munitions wastes.

- Bench-scale test report on membrane processes used to treat ground and surface water contaminated with synthetic organic chemicals (SOCs).

Control Technologies

- Research report on the ADVACATE applicability to DoD boilers and results of the field pilot evaluation.

- Report on innovative technologies for controlling metals and organics resulting from waste incineration.

Pollution Prevention

- Research report on the practicality of new systems and/or chemicals for replacing ozone depleting compounds used in shipboard cooling and fire protection.

- Progress report on test systems and procedures to evaluate feasibility of super-critical CO_2 cleaning/degreasing.

FUNDING ($M):

	FY92	FY93	TOTAL
SERDP	9.7	3.0	12.7

RESEARCH ACTIVITY: Carl R. Gerber, Office of Research and Development (RD-674), United States Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, FTS 260-8821; Fax 260-0552.

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Installation Restoration and Waste Management Technology Development and Demonstration (DoD)

OBJECTIVE:

The Department of Defense and other federal agencies have conducted extensive research on methods to detect and monitor soil, surface water, sediment, and groundwater contamination and to restore contaminated sites for beneficial use. While the feasibility of these technologies has been determined, many have not been carried to full scale demonstration or transitioned to implementation. This proposal is to advance technologies toward implementation, demonstrate the most promising technologies, evaluate their effectiveness, secure regulatory concurrence and provide specific selection and design criteria to the user community to allow implementation thus, reducing long-term costs and expediting site restoration. This initiative will also address pollution prevention, waste reduction, and materials substitution through a hierarchial sequence of finding substitute materials which do not pollute, and modifying the processing to avoid pollution and as a last resort, to treat, process, and dispose of waste in an environmentally acceptable manner.

APPROACH:

The Services, using defense environmental restoration and operations and maintenance funds, have for the past decade conducted extensive research and developed technologies which will allow remediation of contaminated sites in a more efficient and cost effective manner. Funding for continued development and demonstration of these technologies in FY92 is not available from DERA or O&M accounts due to pre-emption by projects essential to protect human health and the environment and by congressionally required reductions in base operations and maintenance funds. This proposal is to fund initiatives previously programmed by the Services, which are of a priority nature and which can be implemented in FY92. As a condition of receiving funds, Service activities will develop specific selection and design criteria which will be shared with others within DoD, other federal agencies and the private sector. Where implementation of the technology will require modifications of military specifications, directives, orders or technical manuals, the Service conducting the technology development will initiate the changes on behalf of DoD. All initiatives under this project are executable within FY92.

Additionally, to bring about an orderly transition of technology from development through implementation, an evaluation of DoD environmental requirements and non-DoD sources of technology will be made and a long-term strategy and plan will be developed. This initiative will be conducted with involvement and oversight by the Deputy Assistant Secretary of Defense (Environment) (DASD(E)) and Director, Defense Research and Engineering (DDR&E).

BENEFITS:

The knowledge and experience gained through the near term implementation and demonstration of these most promising technologies will greatly assist in improving the remediation of many of the contaminated sites throughout DoD. These benefits would be in the form of faster, cheaper, and better cleanup accomplishments than present. Many of these projects have been carried out collaboratively with other interested agencies, therefore, benefits of proven technologies would be applicable across similar problem areas, both public and private. The further development and application of innovative technologies will also address pollution prevention from base support, industrial maintenance and logistics operations. This program will show immediate avoidance benefits in cost and quantity of pollutants; however, the maximum rate of potential savings would accrue and culminate over a number of years.

FUNDING ($000):

DoD Total $37,700

RESEARCH TITLE: Composting of Explosives Contaminated Soil

OBJECTIVE: To complete the development of composting as a method to reduce the concentration of explosives in soil or sediment to environmentally acceptable levels.

PROBLEM ADDRESSED: A number of U.S. Army installations have sites with explosive-contaminated soils and sediments. Although a rotary-kiln incinerator system has been demonstrated as an effective treatment technology, the treatment costs are high.

VALUE: Composting offers an alternative treatment technology which has the potential to effectively degrade explosives in soil and sediment at a significantly lower cost. The residual material could be readily revegetated as part of the site restoration effort.

ACCOMPLISHMENTS TO DATE: A field demonstration at Louisiana Army Ammunition Plant proved that composting of explosives can reduce the levels of trinitroluene (TNT), cyclotrimethylenetrinitramine (RDX), and cyclotetramethylenetetranitramine (HMX), to acceptable levels. The final composted product from the Louisiana site was subjected to toxicological testing by the Army Biological Research and Development Laboratory (BRDL) and the data indicated that the finished compost exhibits little concernable toxicity. An engineering cost analysis and process design was completed for the composting of explosives-contaminated soils. This analysis indicated the need for a field test to optimize conditions to achieve the most cost effective composting process. A pilot scale optimization study was initiated at the Umatilla Army Depot Activity (UMDA) in FY90. Initial work was performed to determine the optimum amendment strategy and develop a means to homogenize samples for laboratory analysis. Two separate types of composting methods are being used to investigate the broad range of process conditions. Aerated static piles are being used to determine the maximum soil throughput while a mechanically mixed in-vessel composter, fabricated for this pilot test, is being used to conduct kinetic rate optimization studies. Toxicological testing is being performed at all phases of the program. The initial results from the optimization study are so encouraging that the regulators want to initiate an interim Record of Decision to use composting to remediate the National Priority Site (NPL) at UMDA. The results of the optimization study will be used to develop a full scale bioremediation field demonstration design to be used at UMDA. Due to the uniqueness of this technology, the first year of implementation will require the guidance of research and development personnel familiar with the technology.

FUTURE PLANS/MILESTONES:

Initiate Windrow Pilot Demonstration	FY 92
Record of Decision to Compost UMDA NFPL Site	FY 92
Complete Windrw Pilot Demonstration	FY 92
Finalize Procurement/Fabrication Guidance	FY 92
Initiate Full-Scale Field Demonstration at UMDA	FY 92
Implementation Guidance/Final Report	FY 93
Provide Necessary Operator Training As Required	FY 94
Bioremediation of UMDA NPL Site Completed	FY 95

AVAILABLE DOCUMENTATION:

Final Technical Report, Composting of Explosives, U.S. Army Report, DRXTH-TE, 1982.

Final Technical Report, Composting Explosive/Organic Contaminated Soils, USATHAMA AMXTH-TE-CR-86077, May 1986.

Final Technical Report, Field Demonstration-Composting of Propellants Contaminated Sediments at the Badger Army Ammunition Plant (BAAP), U.S. Army Report, CETHA-TE-CR-89061, March 1989.

Final Technical Report, Evaluation of Composting Implementation: A Literature Review, U.S. Army Report, TCN-89363, July 1990.

Final Technical Report, Proceedings for the Workshop on Composting of Explosives Contaminated Soils, U.S.Army Report, CETHA-TS-SR-89276, September 1989.

Final Technical Report, Evaluation of Composting Implementation, Unnumbered Report, USATHAMA, August 1990.

Final Technical Report, Characterization of Explosives Processing Waste Decomposition Due to Composting, U.S. Army Report, ORNL/TM-11573, January 1990.

FUNDING ($000)

FY 92
500

RESEARCH ACTIVITY: USATHAMA, CPT Kevin Keehan, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD, 21010-5401, (410) 671-2054.

RESEARCH TITLE: Nondestructive Decontamination of Chemical Agent-Contaminated Structures

OBJECTIVE: To identify and develop an innovative, nondestructive technology to decontaminate Army facilities and equipment contaminated by chemical agents and explosives for the purpose of preparing them for reuse or excessing.

PROBLEM ADDRESSED: The U.S. Army owns and operates ammunition plants, arsenals, and depots involved in the manufacture, processing, loading, and storage of chemical agents, pyrotechnics, explosives, and propellants. These operations have resulted in the contamination of buildings and a variety of processing and handling equipment. Many of these facilities are in an inactive or standby status and are candidates for excessing actions. In some cases, the contaminated buildings have significant reuse potential for conversion to other operational use. The technology being developed in this program has the potential to decontaminate Army facilities in a cost-effective and environmentally acceptable manner without destroying structural integrity.

VALUE: Results of this effort will demonstrate the feasibility of decontaminating a chemical agent contaminated facility in place for possible reuse or will allow demolition of the facility without restrictions for disposal.

ACCOMPLISHMENTS TO DATE:

a. Laboratory and bench scale pilot testing has been completed with favorable results, FY83-89.

b. A chemical agent contaminated building at Rocky Mountain Arsenal has been identified and assessed during FY89-90 for use in subsequent field demonstration.

c. A draft test plan has been prepared and is in review.

d. The contracting mechanism is in place to begin task.

e. Site support requirements and safety requirements have been defined for conduct of task.

FUTURE PLANS/MILESTONES:

Complete Test Plan	FY 92
Complete Safety Plan	FY 92
Complete Site Plan/Safety Submission	FY 92
Complete Equipment Design and Procure Equipment	FY 92
Complete Test Site Preparation/Equipment Installation	FY 92
Complete Test	FY 93
Final Technical Report	FY 93
Prepare Cost Analysis Data	FY 93
Full Scale Design/Implementation Guidance	FY 93
Implementation Assistance	FY 94

AVAILABLE DOCUMENTATION:

Final Technical Report, Development of Novel Decontamination Techniques for Chemical Agents (GB, VX, HD) Contaminated Facilities, Phase I - Identification and Evaluation of Novel Decontamination Concepts, USATHAMA Report ORXTH-TE-CR-83208, February 1983.

Final Technical Report, Development of Novel Decontamination and Inerting Techniques for Explosives-Contaminated Facilities, Phase I - Identification and Evaluation of Novel Decontamination Concepts, USATHAMA Report ORXTH-TE-CR-83211, July 1983.

Final Technical Report, Development of Novel Decontamination and Inerting Techniques for Explosive-Contaminated Facilities, Laboratory Evaluation of Concepts, Phase II - Laboratory Evaluation of Novel Explosives Decontamination Concepts, USATHAMA Report AMXTH-TE-TR-85009, March 1985.

Final Technical Report, Development of Novel Decontamination Techniques for Chemical Agents (GB, VX, HD) Contaminated Facilities, Phase II - Laboratory Evaluation of Novel Agent Decontamination Concepts, USATHAMA Report AMXTH-TE-TR-85012, June 1985.

Final Report, Design Support for a Hot Gas Decontamination System for Explosives-Contaminated Buildings, Maumee Research and Engineering, April 1986.

Final Report, Pilot Plant Testing of Caustic Spray/Hot Gas Building Decontamination Process, USATHAMA Report AMXTH-TE-CR-87112, August 1987.

Final Report, Pilot Plant Testing of Hot Gas Building Decontamination Process, USATHAMA Report AMXTH-TE-CR-87130, October 1987.

Final Report, Demonstration of the Hot Gas Decontamination System for Chemical Agents: Task 3 Final Report, USATHAMA Report CETHA-TE-CR-89168, August 1989.

FUNDING ($000)

FY 92
3,500

RESEARCH ACTIVITY: USATHAMA, Wayne Sisk, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Grounds, MD, 21010-5401, (410) 671-1559.

RESEARCH TITLE: Nondestructive Decontamination of Explosive/Propellant Contaminated Process Equipment

OBJECTIVE: To develop and implement a cost-effective, nondestructive, and environmentally acceptable method to decontaminate contaminated process equipment.

PROBLEM ADDRESSED: The Army has tons of two types of explosive-contaminated metal that require decontamination: process equipment and exploded ordnance scrap. Prior to excessing the process equipment and the ordnance scrap, the metal must be decontaminated and certified contaminant free (5X). In many cases the process equipment may be inaccessible internally to allow adequate decontamination and sampling for certification purposes. The technology being developed will allow cost effective decontamination of internal and external surfaces. This process has particular application for contaminated process equipment requiring decontamination for reuse. Current decontamination methods are generally destructive and preclude the reuse of equipment.

VALUE: The results of this effort will provide Army ammunition plant and depot operators with a cost-effective, nondestructive and environmentally acceptable alternative to excessive and destructive decontamination by incineration.

ACCOMPLISHMENTS TO DATE: Based on conceptual and laboratory evaluations, a hot gas process involving in situ decontamination of structures using burner exhaust gases was developed. A pilot test program on contaminated process equipment (sewer lines, pumps, etc.) was completed August 1989 at Hawthorne Army Ammunition Plant (HWAAP).

FUTURE PLANS/MILESTONES:

Upgrade Hawthorne AAP Pilot Test Equipment as a Result of Pilot Test Lessons Learned	FY92
Prove-out Test of Equipment Upgrades	FY92
Assist Picatinny Arsenal with Evaluation of Hot Gas Technology for Arsenal Use	FY92
Economic Analysis of Hot-Gas Equipment Decontamination Technology	FY93
Finalize Procurement/Fabrication Guidance for Hot Gas Equipment Decontamination	FY93
Provide Training and Support to Potential Users	As Required

AVAILABLE DOCUMENTATION:

Final Technical Report, Development of Novel Decontamination and Inerting Techniques for Explosive-Contaminated Facilities, Phase I - Identification and Evaluation of Novel Decontamination Concepts, USATHAMA Report DRXTH-TE-CR-83211, July 1983.

Final Technical Report, Development of Novel Decontamination and Inerting Techniques for Explosive-Contaminated Facilities, Laboratory Evaluation of Concepts, Phase II -Laboratory Evaluation of Novel Explosives Decontamination Concepts, USATHAMA Report AMXTH-TE-TR-85009, March 1985.

Final Report, Design Support for a Hot Gas Decontamination System for Explosives-Contaminated Buildings, Maumee Research and Engineering, April 1986.

Final Report, Pilot Plant Testing for Caustic Spray/Hot Gas Building Decontamination Process, USATHAMA Report AMXTH-TE-CR-87112, August 1987.

Final Report Technical Report, Pilot Test of Hot Gas Decontamination of Explosives-Contaminated Equipment at Hawthorne Army Ammunition Plant (HWAAP) Hawthorne, NV, USATHAMA Report CETHA-TE-CR-90036, July 1990.

FUNDING

FY92 ($K)

300

RESEARCH ACTIVITY: USATHAMA, Erik Hangeland, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Grounds, MD, 21010-5401, (410) 671-1559.

RESEARCH TITLE: Clean Energy/Conservation

OBJECTIVE: To demonstrate an installation wide, comprehensive energy conservation program that improves the environmental compliance status of installation utilities and industrial sources and meets the new DOD Energy Management Goals of reducing energy usage and costs by a least 20%. The strategy will employ the required strategies for meeting these goals, quantify the environmental compliance benefits resulting from energy conservation and serve as a prototype for DoD wide application. This project will both develop implementation procedures and demonstrate the effectiveness of a comprehensive, coordinated energy conservation program based on state-of-the-art technologies.

APPROACH: In the early 1980's, DoD vigorously pursued an energy management program designed to reduce its energy consumption and costs. Through this effort, overall facility energy consumption in 1985 was decreased by 20% compared to 1975, resulting in a cost avoidance of several billion dollars. Unfortunately, these savings were achieved through the application of "quick and easy" energy initiatives. New energy goals were established by the President in Executive Order 12759, and require another 20% reduction in facility energy use over the next decade. The Deputy Secretary of Defense issued specific guidance in March 1991 for meeting these energy reduction goals, reducing energy costs, and quantifying environmental compliance benefits from pollution prevention. To meet these new energy, environmental and financial requirements will require that we aggressively employ state-of-the-art technologies for both energy management and conservation.

This program will evaluate an installation's energy production and use as an integrated, interdependent system. Energy conservation and management involves both thermal and electrical energy consumption, and will take advantage of meeting the demands for both energy forms concurrently. To be realistic, the program will be accomplished using available installation resources and supporting engineering services, and will follow established program procedures as much as possible. This program will also identify and document environmental compliance benefits that are the result of implementing the energy conservation projects.

The program's general approach will include:

(1) a procedure for tracking the energy use on an installation

(2) a mechanism for identifying and selecting relevant energy reduction options

(3) a technique for coding and prioritizing options

(4) a procedure for quantifying environmental compliance benefits

(5) a procedure for developing a phased implementation plan

This approach will be applied to a typical installation and will be cost effectively implemented with minimal impact on installation productivity.

This low energy installation will provide both DoD and the nation with the technical proof-of-concept required to rekindle interest in facility energy conservation investment.

BENEFITS: Reduction in facility energy cost and consumption of a least 20% will be demonstrated without sacrificing comfort or productivity. Additional benefits include reduced fossil fuel consumption and improved environmental emissions. There is potential for widespread application throughout DoD and the nation.

PARTNERS AND RELATED ACTIVITIES: The extensive experience of DOE laboratories and private research organizations (e.g. EPRI, Edison Electric Institute, GRI) in specific energy saving technologies and energy monitoring will be incorporated. This allows for real world testing of emerging technology. DoD contractors who have demonstrated expertise in energy auditing, applying energy conserving technologies, and developing energy management strategies will be employed during the program. The experience of EPA laboratories in quantifying environmental benefits resulting from energy conservation will be employed. Selection of the candidate sites and technologies to be demonstrated will be coordinated among the Tri Services.

MILESTONES:

Select demonstration sites	FY92
Evaluate current energy use patterns	FY92
Inventory and prioritize energy saving technologies, and document environmental benefits	FY92
Develop energy conservation strategy and design conservation demonstration projects	FY92
Implement projects and conduct demonstrations FORSCOM Funding	FY92-95
Evaluate results and transfer technology	FY93-96

FUNDING ($M):

	FY92	FY93	FY94	FY95	FY96	TOTAL FY92-96
SERDP	2.7					2.7
FORSCOM		6.8	9.6	3.4	1.2	22.9
						25.6

RESEARCH ACTIVITY: U.S. Army Construction Engineering Research Laboratory, ATTN: CECER-ES (Dr. D. Joncich or Mr. G. Schanche), P. O. Box 9005 Champaign, IL 61826-9005, (217) 373-7275

RESEARCH TITLE: Unexploded Ordnance (UXO) Detection

OBJECTIVE: To develop and demonstrate the use of nonintrusive geophysical techniques to detect, identify, and plot subsurface unexploded ordnance.

PROBLEM ADDRESSED: One of the most important aspects of hazardous waste site remediation is the thorough characterization of the site itself. The detection and identification of unexploded ordnance is an important aspect of site characterization where unexploded ordnance contamination has been identified or is suspected.

VALUE: This effort will result in more accurate, safer, and less expensive UXO site characterization and remediation. Additionally, the nonintrusive geophysical techniques and systems developed and improved as part of this effort are not limited to surveying for UXO. They will enhance investigations and characterizations of sites contaminated with more routine environmental pollutants as well.

ACCOMPLISHMENTS TO DATE: Several systems have been developed to help achieve this objective: Surface Towed Ordnance Locator System (STOLS); Ground Penetrating Radar Ordnance Search System (RADAR); and Vehicle Mounted Ordnance Detector (VMOD). STOLS is an automated ordnance locator system employing magnetometry technology for rapid and reliable reconnaissance of large contaminated areas. RADAR is an automated ordnance detector system employing electromagnetic pulse induction. All three systems are in advanced prototype form and have been tested in areas where known ordnance items have been buried at known depths and orientations. All three systems were successful in locating and providing information regarding the location and caregorization of subsurface unexploded ordnance. Other systems/techniques that will be developed as part of this effort include: GDT which introduces a series of vibrations into the ground that are recorded with a string of receivers. A computer interprets the data and provides an image of subsurface inclusions.

FUTURE PLANS/MILESTONES:

Field Testing - All Systems	FY 92 - FY 93
Comparison Testing	FY 92 - FY 93
Improve Sensing Techniques	FY 92 - FY 95
Complete Implementation of Technical Data Package	FY 93
Investigation, Development, and Demonstration of New Sensing Techniques	FY 92 - FY 98

FUNDING ($000)

FY 92

1,100

AVAILABLE DOCUMENTATION:

Draft Report, Surface Towed Ordnance Locator System, NAVEODTECHEN.

Draft Report, Development and Implementation of Buried Waste Detection and Imaging Procedures for Geophysical Diffraction Tomography, USATHAMA Report, Oak Ridge National Laboratory, June 1988.

RESEARCH ACTIVITY: USATHAMA, James Arnold, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Grounds, MD, 21010-5401, (410) 671-4811.

RESEARCH TITLE: Biomonitoring

OBJECTIVE: To develop biomonitoring systems rugged and simple enough to be operated by personnel in a mobile biomonitoring facility.

PROBLEM ADDRESSED: There is a need for more sensitive means to identify health and ecological hazards resulting from exposure to varying concentrations and species of hazardous materials which can occur in activities with complex, heterogeneous waste mixtures. Current safety guidance is based upon extrapolated correlation of toxicological effects with chemical mixtures. It is necessary to develop a means for rapid, on-site indication of exposure hazard conditions that currently exists.

A mobile biomonitoring facility would provide for field demonstration of biological assessment technology.

ACCOMPLISHMENTS TO DATE: Integrated biological assessment concepts employing molecular biology, chemistry, and nonmammalian sentinel species are planned for evaluation and development. Biomonitoring systems for field testing complex mixtures are being fabricated and employed at Army effluent streams and are being proposed for hazardous waste sites. The use of this technology facilitates compliance with the Clean Water Act, Resource Conservation and Recovery Act and Comprehensive Environmental Response, and Liability Act requirements and in the efficacious expenditure of resources in the Defense Environmental Restoration Program. In addition, the use of this research biology has been incorporated into the ongoing environmental compliance program of Aberdeen Proving Ground's installation restoration program.

FUTURE PLANS/MILESTONES:

Complete Field Demonstration and Initiation Technology Transfer FY92

AVAILABLE DOCUMENTATION: None at this time.

FUNDING ($M):

FY92
1.2

RESEARCH ACTIVITY: USATHAMA, Dr. James Arnold, U.S. Army Hazardous and Toxic Materials Agency, Aberdeen Proving Grounds, MD 21010-5401, (410) 671-663-4811.

RESEARCH TITLE: HAZMIN Technology for Tactical Vehicle Maintenance Operations

OBJECTIVE: To develop, evaluate, and implement technology which will significantly reduce hazardous waste generation at Army depots.

APPROACH: Army depot operations involving tactical vehicle maintenance operations generate hazardous waste streams as the result of painting, paint stripping, degreasing, and plating processes. New technology to decrease the amount of waste produced is needed because of the high costs, liability, and potential for increased restrictions associated with present methods of treatment and disposal.

BENEFITS: The successful development and implementation of technologies to improve paint application efficiencies, extend the lives of chemical paint strippers, recycle blast media, and regenerate plating solutions will significantly reduce waste generation at Army depots.

PARTNERS AND RELATED ACTIVITIES:

U.S. Army Depot Systems Command
Activities of other DoD agencies will be monitored
DoD Joint Depot Environmental Panel

ACCOMPLISHMENTS TO DATE: A survey of Army depots identifying potential HAZMIN projects and ongoing waste minimization efforts has been completed. Thus far the results of this survey are the bases for specific efforts to develop innovative HAZMIN technologies in the next several years. Plastic media blasting has been evaluated and successfully implemented at several depots. The evaluation of transfer efficiencies of high volume low pressure paint guns has been completed at Sacramento Army Depot (SAAD). A system to extend the life of an alkaline paint stripping bath via filtration is undergoing demonstration testing at Letterkenny Army Depot (LEAD). The feasibility of using electrodialysis to regenerate chromic acid solutions is being evaluated at Corpus Christi Army Depot (CCAD).

FUTURE PLANS/MILESTONES:

Complete field demonstrations at Letterkenny and Corpus Christi Army Depots	FY92
Assist depots with implementation of paintings and degreasing/ cleaning technologies	FY92-93
Complete Evaluation of electroless nickel plating waste reduction technologies at SAAD, CCAD, and Red River AD	FY92
Complete evaluation/demonstration of new, less/non-hazardous paint stripping and degreasing formulations	FY93

Complete evaluation/demonstration of a disposal system for paint application/stripping wastes that is more environmentally safe and more cost effective than landfill FY94

Initiate efforts to demonstrate the cost-effective recovery of heavy metals from electroplating sludges FY95

FUNDING ($M):

	FY92	FY93	FY94	FY95	FY96	TOTAL FY92-FY96
SERDP	1.0	0.2	0.60	0.60	0.60	3.00

AVAILABLE DOCUMENTATION: None at this time.

RESEARCH ACTIVITY: U. S. Army, Production Base Modernization Activity, ATTN: AMSMC-PBC, Picatinny Arsenal, NJ 07806-5000, (201) 724-6309

RESEARCH TITLE: Analytical Methods/Instrumentation Development

OBJECTIVE: To develop sampling and analytical methods to identify environmental contaminants and Standard Analytical Reference Materials (SARMs) for quality control program utilized by the environmental surveys and the treatment development projects.

PROBLEM ADDRESSED: Many of the current analytical methods for Army specific compounds cannot achieve low detection limits with acceptable precision and accuracy. The requirements for the analytical methods are identified by reviewing the lists of suspected contaminants at installations scheduled for an environmental survey. Method certification work is performed in a laboratory according to USATHAMA's Quality Assurance Program to develop the necessary detection limits, precision and accuracy.

VALUE: Analytical methods/instrumentation developed will achieve low detection limits with acceptable precision and accuracy for Army specific compounds.

ACCOMPLISHMENTS TO DATE: Analytical methods continue to be developed or refined to support installation restoration programs and research and development projects. SARMs are developed and added to the standards repository, with USATHAMA's published plan. An updated Quality Assurance Program has been prepared and published as a guide to contractors and to the program-performing laboratories.

FUTURE PLANS/MILESTONES:

Field Portable GC/MS	FY 92
Agents Analytical Development	FY 92 - FY 94
Phosphoric Acid Method Development	FY 93
SARMs Development-Explosive Degradation Product	FY 93
Develop Required Analytical Methods and SARM	FY 92 - FY 96

AVAILABLE DOCUMENTATION:

Development of a Simplified Field Method for the Determination of TNT in Soil, CRREL Special Report 90-38.

Development of a Field Screening Method for RDX in Soil, CRREL Special Report (in press).

Transformation Products of Nitroaromatics and Nitramine: Literature Review, CRREL Special Report 90-2.

FUNDING ($M):

FY92	FY93
1.20	1.3

RESEARCH ACTIVITY: USATHAMA, Douglas Stevenson, US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Grounds, MD, 21010-5401, (410) 671-1569.

RESEARCH TITLE: Biomagnetic Separation Processes for Priority Pollutants

OBJECTIVE: To evaluate the use of biomagnetic separation processes for removal of heavy metals from storage ponds and plant effluent streams.

APPROACH: The use of microorganisms for recovery of heavy metals from solution is well established. This technology has been successfully adapted for efficient and cost-effective industrial waste stream purification and for recovery of precious metals. One such technique which was recently developed is called "biomagnetic separation." In this technique, some microbes which are pre-treated with select substrates produce a coating which can "bioaccumulate" up to four times the microbe's weight of heavy metal ions. The microbes, which become paramagnetic in the process, can then be concentrated and removed from solution by high gradient magnetic separation (HGMS). Recently, preliminary studies have shown that certain strains of microbes, when properly pretreated, can efficiently remove not only metal ion wastes from solution but a variety of toxic organics -- including halogenated organics and biphenyls as well. The proposed project would expand on these earlier studies to (1) identify the priority pollutants of military significance which can be removed from solution using this technique; (2) identify additional strains of microbes which may be used in this process; (3) evaluate the impact of exposing the microbes to mixed wastes; (4) identify the most efficient means of raising the microbes for treating storage ponds and plant effluent streams; and (5) establish a data base adequate for the design and demonstration of a pilot-scale Biomagnetic Separation Priority Pollutant Waste Treatment System.

The microbes which have been tested with organic pollutants are "dissimilatory sulphate-reducing bacteria (SRBs)." SRBs are strict anaerobes and, as such, may not be suitable for all types of applications. In addition, the strains studied are mesophiles, i.e., they grow within a narrow temperature range and are intolerant to high temperature; they are also sensitive to high salt content, acid conditions, and pressure. Under the proposed project, additional strains of SRBs will be tested, including thermophilic and thermoacidophilic strains such as those which have been discovered thriving in the environmental extremes of ocean floor geothermal vents, volcanic ponds, and hot springs. Thermophilic SRBs not only tolerate more extreme conditions, they also reproduce much more quickly than mesophilic. In addition, the formation of the coating and the interaction with the pollutants may proceed much more rapidly at higher temperatures. Other SRBs are active in Antarctic Ocean waters at -40°C, which might make them very useful for purifying waters in colder climates without the necessity or expense of heating the water. Another category of microbe, ferro-manganese-depositing (FMD) bacteria, will be studied as well. These microbes also produce a coating which incorporates many different metals (in addition to iron and manganese), but are aerobic rather than anaerobic. Finally, mixtures of the two will be evaluated; initially, the FMD will be active, while the SRBs will remain dormant. Once the FMD have used up the local oxygen they will become dormant while the SRBs will take over. The various microbes will be tested for their ability to take up significant levels of compounds which represent major categories of priority pollutants (e.g., heavy metals, organochlorine pesticides, organophosphorus pesticides, PCBs, phenols, polycyclic aromatics, explosives,

etc.); which exhibit high solubility in water and low volatility; which are, or have been, in heavy use; and which are of military importance. Those microbes which show versatility of application will be further down-selected on the basis of tolerance to high levels of pollutant, pH extremes, salinity, temperature extremes, and pressure, and which have minimal carbon source requirements. (Several strains of both categories of microbes are true autotrophs, which may make them less expensive to use in large-scale operations.)

A number of different configurations are possible with this technology. The entire process can be set up in a fully-integrated reactor system, in which the microbes are raised, pre-treated, mixed with the pollutant stream, and cycled through the HGMS. Alternatively, the microbes can be pretreated and used to seed a contaminated body of water. Once the microbes have had a chance to sorb the pollutants, the water can be processed through a separate HGMS. In this scenario, the HGMS can be mobile -- several mobile HGMS systems are currently in use in the kaolin industry to purify clays -- and the mobile unit used to process many different bodies of water in many different locations. If the body of water already contains suitable microbes (both SRBs and FMDs are ubiquitous), it may be possible to add substrates to the pond which encourage growth of the native bacteria; the HGMS can then be used to remove the paramagnetic microbes with their burden of pollutants. Finally, it has been well established that deactivated biomass, e.g., coating stripped from bacteria, can often take up as much, if not more, heavy metals as the living microbes. It may be possible to design a reactor bed which produces the sorbent coating; this coating would be stripped form the microbes before it is mixed with the pollutant water. The treated water would then be pumped through the HGMS for final purification. Data will be developed to evaluate each of these potential configurations during the program.

It should be noted that the microbes best suited for some applications will be less well suited to others. On this mutual program, microbes which are relatively versatile, i.e., which are capable of taking up a number of different pollutants or pollutant classes, and which become strongly paramagnetic during pretreatment, will be selected for use in the later stages. Data generated with the other microbes which undergo evaluation may be extremely useful for tailoring biomagnetic separation processes or systems for specialized applications. During the later stages of the program, emphasis will be placed upon optimizing and scaling up bacterial growth, coating production, and pollutant uptake to levels suitable for use in a reactor, using the chosen microbe (or mixture of microbes). As many different HGMS designs have already been developed for many different applications, a simple study will be conducted to evaluate available designs and to select the one best suited for demonstrating the Biomagnetic Separation Priority Pollutant Waste Treatment System.

BENEFITS: The National Defense Authorization Act for Fiscal Year 1991 states: "The committee believes that the defense establishment has a clear self-interest in the development of better technologies for . . . more cost-effective methods of disposal, identification, treatment, and cleanup of sites containing toxic, radioactive, and hazardous materials. . . . In addition, because some hazardous or nuclear waste will continue to be generated as by-

products of defense operation, the defense establishment needs more investment in processes and methods to reduce waste, to address waste minimization, and to address hazardous materials substitution." The proposed studies would help identify new, safe and cost-effective methods both for cleaning up current heavy metal, toxic chemical, and mixed waste ponds and for treating effluent streams produced by future defense operations.

MILESTONES:	FY
Efficiency of SRBs demonstrated with 20 selected pollutants.	92
Down-select to three best candidate micro-organisms completed.	92
Optimum parameters for growth and HGMS removal of three candidates established; down-select to one microorganism.	93
Concept for pilot plant completed.	93
Detailed design and fabrication completed.	94
Pilot-scale demonstration completed.	94

FUNDING ($K):

FY92	FY93
150	252

RESEARCH ACTIVITY: U.S. Army Chemical Research, Development, and Engineering Center, ATTN: SMCCR-TDB, Aberdeen Proving Ground, Aberdeen, MD 21010-5423, (301)671-1396

RESEARCH TITLE: Use of Biomaterials for the Removal of Hazardous Chemicals from Contaminated Soils

OBJECTIVE: The identification and utilization of microbially produced surface active agents (SAAs) for the solubilization of hazardous chemicals and their removal from contaminated soil.

APPROACH: A variety of different SAAs (lipoproteins, glycolipids, peptides, etc.) with powerful solubilizing or emulsifying activity have been identified as the products of microorganisms that are capable of growth on relatively insoluble chemicals. These include materials such as coal, oils, petroleum, asphalt and pesticides. This program would be aimed at the isolation or development of microbial SAAs that are specific for the target chemicals in the particular site undergoing remediation. The search for these specific SAAs would include isolation of microorganisms from the contaminated site and enrichment on the various pollutant chemicals, as well as evaluation of various biosurfactants that have already been identified in the literature. Initial studies would be conducted with both pure compounds in the laboratory and well as actual samples of the contaminated soil. The efficacy of the SAAs in removing the pollutants would be determined by use of model slurry reactors corresponding to systems under development by USATHAMA. For larger studies the SAAs could be produced in bulk in the new CRDEC Process Engineering Facility.

Task 1. Development of test and evaluation procedures to determine the efficacy of SAAs in solubilizing model pollutant chemicals. This work would be coordinated with USATHAMA to assure compatibility with their bioslurry reactor demonstration project. Selection of several model chemicals.

Task 2. Acquisition of SAAs from commercial or academic sources. Evaluation of the SAAs ability to solubilize the model target chemicals.

Task 3. Enrichment cultures to select microorganisms capable of growing on, and presumably solubilizing the target chemicals.

Task 4. Selection of most promising SAA candidates and evaluation in soil slurry reactors. Both synthetic soil mixtures and actual soil from contaminated sites to be used.

BENEFITS: The types of contaminating chemicals found at a variety of DOD sites have been shown to be amenable to degradation by microorganisms, with the products (if any) being less toxic than the starting materials. However, considerable problems have been encountered by others in attempts to utilize microorganisms for in situ bioremediation. These include poor growth due to environmental factors (temperature, pH, salinity, etc.); difficulty in providing oxygen for aerobic systems; and, lack of accessibility of the contaminants to the organisms due to insolubility or binding to the soil matrix. The removal of the pollutants from the soil through the use of SAAs would allow their biodegradation by microorganisms in bioreactors where the

parameters such as oxygen content, temperature, and pH are maintained at optimal levels.

MILESTONES:

	FY
Task 1.	92
Task 2.	93
Task 3.	94
Task 4.	95

FUNDING ($K):

FY92	FY93
100	230

RESEARCH ACTIVITY: U.S. Army Chemical RD&E Center, ATTN: SMCCR-RSB/Dr. Joseph J. DeFrank, Aberdeen Proving Ground, MD 21010-5423, Phone: (410) 671-3972; FAX (410) 671-2081

RESEARCH TITLE: Waste Stream Cleanup by Enzymatic Oxidation in Non-Aqueous Solvents

OBJECTIVE: The use of solvent extraction and a multi-enzyme oxidation system for the removal and degradation of organic pollutants from wastewater streams.

APPROACH: The proposed system combines elements from a number of different sources and is based on a number of factors. First, it is well known that many of the problem pollutants for the military, in particular, chlorinated aromatic hydrocarbons and explosives, are much more soluble in organic media than in water. Second, it was recently shown that enzymes can not only survive and function in organic solvents but can be stabilized to a considerable degree. Third, the use of hollow-fiber membrane systems can serve as excellent means of bringing aqueous and organic phases in contact without the need for subsequent phase separation efforts. The proposed system would use a hollow-fiber membrane module containing a fluorocarbon or long chain aliphatic hydrocarbon to strip the pollutant chemicals from a waste water stream (e.g., production or research facility). Within the module would be two enzymes: Alcohol Oxidase, which will oxidize added methanol or ethanol to form hydrogen peroxide; and, a Peroxidase, which uses the peroxide to form free radicals that react with the pollutant. This leads to polymerization reactions that form high molecular weight products. The low molecular weight cut-off of the membrane serves to prevent these products from passing back into the clarified aqueous phase. These degradation products can be removed from the solvent as a concentrated material and disposed of by incineration or other method. Previous studies reported in the literature have used Horseradish Peroxidase in aqueous media to demonstrate this technology. For this proposal a peroxidase from a thermophilic microorganism will be used. Such an enzyme is under development by JK Research under a SBIR contract and will be available soon. This enzyme should have greatly enhanced stability.

Task 1. Selection of solvent systems, model pollutants and analytical methodology.

Task 2. Evaluation of enzyme activity and stability in the selected solvent systems with the model pollutant compounds. Initiation of long-term stability testing.

Task 3. Characterization of the products of the enzyme reaction and selection of methods for their efficient removal from the solvent phase.

Task 4. Evaluation of the optimized enzyme(s)/solvent system in a hollow-fiber membrane module with model compounds. Determination of extraction efficiency and enzyme effectiveness. Evaluation of the system with actual waste stream samples.

BENEFITS: The problems that the Army faces in regards to hazardous waste minimization are to some extent the same as those seen nationwide. The pollutant chemicals in the waste streams are often found at very low levels so that a concentration step is required. They are also usually present as mixtures, a fact which makes degradation systems that deal with only a

specific compound impractical. The proposed use of solvent extraction provides the concentration required and the use of a non-specific peroxidase system could potentially deal with any organic pollutant encountered.

MILESTONES:	FY
Task 1.	92
Task 2.	94
Task 3.	94
Task 4.	95

FUNDING ($K):

FY92	FY93
115	200

RESEARCH ACTIVITY: U.S. Army Chemical RD&E Center, ATTN: SMCCR-RSB/Dr. Joseph J. DeFrank, Aberdeen Proving Ground, MD 21010-5423, Phone: (410) 671-3972; FAX (410) 671-2081

RESEARCH TITLE: Enzymatic Decomposition of Energetic Materials

OBJECTIVE: Cooperative experiments carried out at Picatinny Arsenal and Lehigh University demonstrated that Aspergillus fumigatus metabolized the nitrogen released during the aqueous hydrolysis of nitrocellulose (NC). Subsequently, the fungus utilized the glucose split off from the denitrated NC polymer. This was a new and important finding, in view of the previously held ideas regarding the resistance of nitrate esters to biological attack by microorganisms. The advantages of this biotechnology process are immediately obvious in that it can provide a safe and environmentally acceptable way to completely decompose at least one nitrate ester which is widely used in the defense industry.

APPROACH: The approach to be taken in this program is to optimize the initial batch process used to demonstrate the phenomenon, and then to scale it up for use in NC production facilities. Optimization will focus on fungal strain selection and on comparison of A. fumigatus with other microorganisms capable of totally degrading NC. Continuously fed off-the-shelf bioreactors or rotary drum styles are expected to supplant the original batch culture variety of reactor early on in the project. The final stage of development of the program will be a scale-up of the optimum bioreactor design and its inclusion at NC production facilities for management of NC waste streams.

The decomposition of nitrate esters is also feasible using enzymes which have been isolated from various sources. Two processes developed by the principal investigators will be optimized and used for both bioremediation of soils, sediments, and settling ponds and for management of waste streams at production facilities.

The mammalian enzyme glutathione s-transferase (GSH S-transferase) has been used effectively to decompose the dinitrate ester of diethyleneglycol (diethyleneglycol dinitrate) (Gold and Brodman, Patent No. 4,929,552, dated May 29, 1990.) Additionally, the literature contains numerous citations documenting the decomposition of nitroglycerin by GSH S-transferase, and this non-specific enzyme undoubtedly has the capacity to decompose other nitrate esters as well. Moreover, GSH S-transferase is not limited to mammalian sources, and has been reported in a variety of microorganisms as well.

The approach planned is to use the GSH S-transferase system to degrade a variety of nitrate esters under different environmental and physical conditions such as those found at various Army ammunition plants for the purpose of 1) bioremediation of soils and pond sediments, and 2) removal of nitrate esters from waste streams to avoid future environmental contamination associated with their production. Increased specific activity of the enzymes brought about by further purification, and stabilization on support matrices, will simplify the technology and speed the degradative processes.

The principal investigators have developed a process for removal of inorganic nitrate ions from solution during the chemical decomposition of nitrocellulose. Nitrate reductase was induced in bacterial cells, isolated and added to nitrite-containing reaction mixtures as a way to remove nitrite ions from solution and to permit the chemical decomposition of nitrocellulose

to proceed (Gold and Brodman, Patent No. 4,756,832, dated July 12, 1988.) Additional microbial enzymes found in the denitrifying train will be employed as required. As an example, a similar technology utilizing nitrate reductase, also present in enzyme trains of certain denitrifying microorganisms, will allow removal of inorganic ions from ponds or waste water at production facilities.

In summary, the approaches to be taken will be to determine optimum microbial and enzymatic conditions to effect decomposition of nitrate esters and to remediate soils and pond sediments; rates of decomposition will be determined, and the biochemical processes driving the reactions will be characterized; the products of decomposition will be identified to ensure that decomposition products are not hazardous; pilot plant processes using various techniques such as batch culture, continuous flow, gravity feed, rotating drum, etc., will be designed for large-scale biodegradation of nitrate esters in soils, water and production waste streams.

BENEFITS: This program will generate technology that can be utilized to treat hazardous waste stream resulting from the manufacture of energetic materials, provide for an environmentally safe method for the disposal of scrap energetic materials, and provide a method for bioremediation of soils contaminated with energetic materials. The resulting technology can be rapidly transitioned to both the private sector and other government agencies to address these problems. Specific examples include the bioremediation of Badger Army Ammunition Plant, the bioremediation of the ARDEC burning grounds, and various manufacturing waste stream treatments.

PARTNERS AND RELATED ACTIVITIES: Several of the national laboratories are active in this area. Los Alamos National Laboratory has an internally funded program to biodegrade several energetic materials and Lawrence Livermore National Laboratory is in a similar situation. We will take full advantage of this work through our existing DoD-DOE MOU on cooperative energetic material research and development. Another mechanism for technology transfer is through the various contractors that run the Government Owned Company Operated (GOCO) Army Ammunition Plants. Information can be directly transitioned to the private sector through this means.

MILESTONES: **FY**

Optimization studies completed. Rates determined and mechanism elucidated.	92
Reaction products characterized. Remediation technology transferred to other government agencies and industry.	92
Manufacturing waste stream treatment pilot plant treatment initiated.	93
Manufacturing waste stream treatment scale-up demonstrated and technology transferred to manufacturing plants.	93

FUNDING ($K):

FY92	FY93
290	350

RESEARCH ACTIVITY: Dr. Bruce W. Brodman, SMCAR-AEE-BR, (201) 724-5345, Armament Engineering Directorate, U.S. Army ARDEC, Picatinny Arsenal, NJ 08706

RESEARCH TITLE: Extraction & Recycling of LOVA Propellants Using Supercritical Fluids

OBJECTIVE: To identify suitable supercritical fluid solvents for use in extracting and recycling the energetic materials and other ingredients in solid propellants developed for AMC munitions development programs. The focus will be on extraction/separation for recycling of the components of the new class of "LOVA" (low vulnerability ammunition) propellants being developed for gun applications.

BACKGROUND: Supercritical fluids (SF) have two potential environmental-related applications related to energetic materials: destruction via oxidation in SFs (HAZMAT destruction), and "solventless" SF extraction/separation for purposes of recycling (pollution prevention). The first area is being actively pursued (see C&E News, Dec. 23, 1991): the DOD is in the process of negotiating a contract for a pilot plant that uses supercritical water to destroy military toxic wastes. For the long term, recycling should be the preferred approach. There is a fundamental dilemma, however: While the energetic materials, polymeric binders and other ingredients of solid propellants tend to be highly soluble in the (polar) SF solvents used for destructive oxidation (e.g., supercritical H_2O, T_c=374C), the solubility in "inert" solvents (e.g., supercritical CO_2, T_c=31C) that one would like to use for extraction/recycling is too low for the process to be economically feasible.

APPROACH: The proposed research will involve investigation of the effectiveness of polar "modifiers" in increasing the solubility of energetic materials (e.g., HMX, RDX) and binder components in supercritical CO_2. For other systems, modifiers at the 1-5% level have increased solubilities by up to several hundred percent. The research will probe the relationship between modifier molecular structure and its effect on solubility of nitramine energetic materials and other propellant ingredients. The goal will be the identification of polar "modifiers" that a) significantly increase solubility of the solid propellant components in SF CO_2, b) do not result in hydrolysis or other chemical degradation of the propellant ingredients, and c) can either themselves be recycled, or are as close as possible to neat CO_2 in having negligible environmental impact. The research will also involve finding the optimum SF conditions (e.g., temperature, pressure/density) for promising CO_2-polar modifier supercritical solvents.

The approach will include both experimental and theoretical techniques. The experimental work will involve measurement of nitramine (and other ingredient) solubilities in supercritical solvents using a variety of polar modifiers, and under several supercritical conditions (e.g., both close to- and far from- the critical point). Two experimental techniques will be used to measure solubility. One will employ spectroscopic detection using an optical (windowed) supercritical cell; the other will involve expansion (to subcritical conditions) of the supercritical solution, with thermogravimetric analysis of the deposited solute(s). Each technique has advantages in particular situations. The theoretical work will serve to correlate the experimental findings by identifying the relationship between polar modifier molecular structure and its effect on solvent-solute interactions. References

2-4 represent examples of successful use of theoretical methods for correlating/predicting solubilities for other chemical systems/applications. A second use of the theoretical calculations will to reduce the number of supercritical conditions that must by measured by permitting the "phase diagram" to be estimated from a limited number of solubility measurements, thus increasing the number of modifiers that can be investigated.

BENEFITS: Prevention of pollution associated with disposal of Army gun propellants; associated reduction of life-cycle cost of munitions.

PARTNERS: All research will be carried out in-house, but major interactions are expected with Batelle Northwest, University of Delaware, University of Wisconsin, and University of Texas (Austin).

MILESTONES:	FY
Design & construct supercritical optical cell; evaluate published theoretical methods.	92
Measure nitramine solubilities for several modifiers/conditions; tailor & implement most promising theoretical method for this application.	93
Measure solubilities for LOVA binders, plasticizers, stabilizers; correlate/interpret data with theoretical techniques.	94
Laboratory-scale experiments with full propellant formulations; explore recycling schemes; propose most promising schemes for transition to 6.2.	95

FUNDING ($K):

FY92	FY93
150	400

RESEARCH ACTIVITY: U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD 21005-5066; Dr. Jeffrey B. Morris, DSN 298-6148

RESEARCH TITLE: Fate and Transport in Seasonally Frozen Soil and Discontinuous Permafrost

OBJECTIVE: The objective is to develop the ability to predict the influence of soil freezing and discontinuous permafrost on the processes controlling transport and fate of contaminants in soil.

APPROACH: Multiphase transport is a complex process that is not fully understood, particularly in locations that are subject to seasonal soil freezing or underlain by discontinuous permafrost. Knowledge of the effects of seasonal soil freezing, freeze-thaw cycling, and discontinuous permafrost on contaminant migration is lacking. Also there is a need to develop methods to determine hydraulic conductivity and other spatially variable parameters in frozen soils. This information is necessary to predict the extent of subsurface contamination.

Both laboratory and field studies will be used to investigate contaminant migration interactions with soil freezing. Existing transport models will be used as a basis for identifying knowledge gaps that exist concerning discontinuous permafrost soils.

Task 1. Identify knowledge gaps from application of multiphase transport models.

Task 2. Development of hydraulic conductivity measurements in frozen soil.

Task 3. Experiments comparing non-destructive methods for obtaining model parameters.

Task 4. Investigate containment transport and ion diffusion mechanisms in frozen soil.

BENEFITS: Increased knowledge will lead to enhanced ability to predict the transport and fate of contaminants in soils that are seasonally frozen or underlain by discontinuous permafrost. Information obtained will also support cryogenic containment technology.

MILESTONES:	FY
Task 1.	92
Task 2.	93
Task 3.	93
Task 4.	94

FUNDING($K):

FY92	FY93
130	500

RESEARCH ACTIVITY: Dr. I. Iskandar, CECRL-RC, (603) 646-4198, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH 03755

RESEARCH TITLE: Identification and Testing of Non-Ozone Depleting Halon Agents

OBJECTIVE: This research program is aimed at ultimately identifying and testing the best candidate Halon replacement compounds for Army-specific fire fighting applications. This will be accomplished by a coordinated experimental and modeling effort on flame suppression chemistry. Toxic and non-toxic Halon-substitute combustion products will also be identified and measured by laser spectroscopic and mass spectrometric means.

APPROACH: Currently there are no Army research programs to identify new Halon alternatives for Army-specific fire fighting needs. The expectation that industry will supply an adequate number of Halon alternative compounds has not been met. Therefore, the Army is facing a potentially very serious gap in providing fire fighting capability for current and future combat vehicles.

This research will be accomplished by means of detailed experimental flame structure studies coupled with computer simulation models. The aim of this research is the understanding of the chemical and physical mechanisms underlying flame suppression. This knowledge, in turn, will lead to the identification of new classes of fire suppressants. This research will be conducted using a highly instrumented laboratory burner apparatus which employs molecular beam mass spectrometry with laser spectroscopic techniques for species and temperature profile determinations in a laminar flow premixed flame. This flame research apparatus will also be used to determine relative flame quenching characteristics of specific Halon alternative candidates which are identified in the future. In addition to the premixed flame chemistry research, diffusion flames will be studied to determine the importance of transport properties on flame suppression. Toxic and non-toxic Halon-substitute combustion products will be identified and measured by laser spectroscopic and mass spectrometric means.

BENEFITS: The U.S. Army Materiel Command is charged with providing combat vehicles with the ability to extinguish crew compartment fires. The current method of meeting this requirement is the use of total flooding Halon 1301 systems. Clean Air legislation and Army Regulation 70-68 dictate the cessation of the purchase of any new Halons by October 1995. Since these regulations were enacted, data from atmospheric monitors indicate a much larger loss of stratospheric ozone than expected. This, in turn, will most likely lead to an accelerated phase-out of Halon production and use.

PARTNERS: Naval Research Laboratory (Dr. Ronald Sheinson), National Institute of Standards and Technology, Air Force Wright Research and Development Center, and Halon Alternative Research Consortium.

MILESTONES: **FY**

Measurements of flame composition at the extinction and identification of toxic and non-toxic combustion products.	92/93
Development of flame models to predict extinction.	93
Diffusion flame studies.	94
Large scale laboratory and model prediction tests.	95

FUNDING ($K):

FY92	FY93
125	300

RESEARCH ACTIVITY: Dr. Andrej W. Miziolek, Ballistic Research Laboratory, SLCBR-IB-I, Aberdeen Proving Ground, MD 21005-5066, (410) 278-6157

RESEARCH TITLE: Selective Recovery and Re-Use of Heavy Metals in Waste Streams with Bioengineered Polymers

BACKGROUND/OBJECTIVE: Many biologically-derived polymers exhibit selective absorption properties towards heavy metals. In addition, many biologically-derived materials are capable of selective and controlled crystallization of mineral and metal phases from solution. Coupling these attributes would provide the opportunity to couple metal recovery and re-use to produce potentially useful materials. Many classes of biological polymers, including polysaccharides and proteins are known to chelate and react with heavy metals and minerals. For example, chitosan is known to absorb copper and other heavy metals. Using natural polymers as a guide, novel polymers such as chemically modified polysaccharides, or polymers derived from enzymatic-catalysis, could be tailored for specific absorption characteristics.

Additionally, proteins are known to control crystallization of metals and minerals, such as to form cadmium sulfate particles and related inorganic phases. Controlled synthesis and modeling of these type of proteins should provide a rational approach to the design and fabrication of membranes and fibers with specific absorption characteristics. These materials would be synthesized, studied for binding properties, tailored as required, and then evaluated in membrane, film and fiber forms to eventually develop metal recovery systems. The tailorability and versatility of the types of biological monomers that can be incorporated into these systems (e.g., different sugar monomers, different amino acids, and chemically modified analogs of these) provide a wide range of reactivities and secondary structures from which to build the required membrane structures and selectivity.

APPROACH: Selective polysaccharides and proteins will be produced from specific biological systems (e.g., poly-gamma-glutamic acid from bacteria, chitosan from a fungus, pullulan from a fungus, starches from plants, hyaluronic acid from commercial sources), or by chemical synthesis. These base polymers will then be chemically modified in selective fashions to incorporate variations in functional groups (type, stereoregularity, spacing) to study impact on metal chelation. These polymers will be studied in powder, fiber and film forms, as appropriate, to evaluate metal/mineral chelation under a diverse set of environmental factors (e.g., pH, salt, solvents, etc.). Molecular modeling will be used to help guide appropriate choices for functional groups to incorporate into the base polymers. As the second phase of this effort, additional selectivity of these polymers will be incorporated to begin to form specific types of crystals (morphology, size spacing) potentially useful as ceramic precursors for powders or composites, or simply as recoverable metals for reuse in industrial processes.

BENEFITS: Process waters where metal wastes are produced could be continuously cleaned by the use of membranes or woven films made from the polymers formed. These polymers could be reused or run in a continuous removal mode to re-release metals, and the metal/mineral phases could be reused directly or potentially as ceramic precursors. This will avoid pollution burdens due to metal contamination of process waters and also reduce manufacturing costs due to the reuse of these metals in the process.

PARTNERS: U.S. Army Materials Technology Laboratory, University of Massachusetts at Lowell, Massachusetts Institute of Technology

MILESTONES:	**FY**
Initiate production and modification of a series of selective polysaccharides with specific variations in functional groups and spacing. Begin processing these polymers into films and fibers. Begin modeling studies to identify appropriate conformations that will guide the chemical synthesis to optimize chelation and selectivity.	92
Study mineral/metal binding to the polymers formed to determine specificity for specific metal species. Begin studies to identify unique crystal morphologies for potential ceramics and reuse applications.	93

FUNDING ($K):

FY92	FY93
290	550

RESEARCH ACTIVITY: Dr. David L. Kaplan, (508) 651-5525, FAX: (508) 651-5521, U.S. Army Natick RD&E Center, Natick, MA 01760

RESEARCH TITLE: Effects of Sorption, Survival, and Activity on Biological Treatment of Explosives and Organic Compounds

OBJECTIVE: Determine the significance of soil sorption and microbial survival and activity on biological treatment of explosives and organic contaminants.

APPROACH: Explosives and other organic contaminants are often stabilized against biodegradation through sorption onto clays or organic matter in soil. Existing information is unclear as to whether microorganisms can effectively degrade compounds in the sorbed state or if the compounds must be desorbed before they are susceptible to degradation. The availability of the contaminant to the degrading microorganism is of key importance in achieving successful biotreatment. This research will determine the importance of sorption in controlling the bioavailability of explosives and other selected organic contaminants by comparing the diffusion rate and sorption rate of the contaminant. When sorption is limiting to bioavailability, predictive techniques will be developed to relate these limitations to specific soil characteristics. Effects of microbial attachment on degradation rate will be determined by comparing degradation rates of microorganisms held in solution with rates when microorganisms are sorbed to soil surfaces. Radiolabelled cells will be used to determine phase location of the microorganisms and radiolabelled contaminants will be used to assess degradation rates and extent. Results will be used to develop procedures that enhance the accessibility of the contaminants to microbial degradation. Results of these studies will allow prediction of feasibility of various bioremediation protocols. This approach will be successful because it is based on well-established technology in soil science and microbiology.

Several microbial strains and consortia have been developed and marketed that purportedly accelerate degradation of organic compounds or mixtures of compounds in contaminated soils under aerobic and anaerobic conditions. Examples include microorganisms specific for TNT, microorganisms producing powerful oxidases (i.e., the fungus Phanerochaete chryosporium) that degrade a variety of complex organic compounds, potentially including explosives, and microorganisms specific for trichloroethylene (TCE). Conventional wisdom in environmental microbiology suggests that microorganisms introduced to new environments will not survive for long. For example in compost treatment, high temperatures (50-70 degrees Celsius) can be hostile to all but a very limited number of otherwise suitably adapted microorganisms. If commercial microorganisms are effective in a biological treatment system, the time and cost savings achieved will be important; however, if the organisms can not survive long enough to destroy significant levels of the explosives and organic contaminants, then the expense for their purchase and distribution will be wasted. A method is needed to evaluate the ability of commercial organisms to survive and carry out their activity in biological treatment systems. Such an approach will allow managers at sites contaminated with explosives to quickly determine whether a proposed commercial microorganism is suitable for use at that site.

A protocol to assess the survival and activity of microorganisms will be developed in two stages. Stage 1 will demonstrate the persistence of the microorganism in biological treatment systems. In this stage, existing

technology will be modified to detect and enumerate the added microorganisms in the systems. Stage 2 will determine whether the degradational activity of these organisms persists at acceptable levels with prolonged incubation (up to three months) in the treatment systems. Following initial development of the protocol, a series of tests will be run to determine the survival and effectiveness of the test organism under a range of pH, temperature, and organic loading conditions. The protocol will then be applied to a variety of commercial organisms and treatment systems and field tested to verify its utility.

BENEFITS: Development of procedures for determining the significance of soil sorption of both contaminants and microorganisms to microbial degradation of explosives and other organic contaminants will provide numerous benefits to bioremediation efforts by DOD and others. These include improved understanding of the role of sorption in regulating microbial degradation of explosives and organics, improved understanding of the relationship between biodegradation and soil characteristics, and procedures to improve biodegradation of explosives and organics in the soil matrix. These efforts will also contribute materially to other bioremediation approaches directly involving soils and groundwater. Evaluation of the movement and bioavailability of explosives and organic contaminants in the soil will improve DOD capabilities for predicting the environmental fate of these contaminants and improve feasibility of *in situ* bioremediation and other bioremediation strategies. The developed procedure will be available for use by other agencies and by firms in the private sector.

Development of a rapid, relatively inexpensive, and easily applied protocol for determining the persistence and activity of commercial microbial strains in biological treatment systems will yield numerous tangible benefits to DoD and the Nation. These include: (1) rapid assessment of the ability of a proposed microorganism or microbial consortium to survive and maintain activity in a given biological treatment system, and (2) large savings of costs and time that would otherwise be lost in conducting bench- and pilot-scale testing using commercial organisms that are incapable of surviving and carrying out degradational activity in a biological treatment environment. This procedure will be available for use by DOD, DOE, and the private sector. This work is a key component in the development of several microbially-based treatment technologies and has application to several other work areas funded by the Army.

PARTNERS AND RELATED ACTIVITIES: Development of bioremediation technology for explosives and organic contaminants has been conducted by the Army and Navy for several years. Other partners include DOE and the States. This work is complementary to other work funded by the Army.

MILESTONES:	FY
Compare diffusion rates of explosive with microbial degradation rates to determine which is limiting. Obtain representative species of microorganisms and identify candidate biological treatment systems; identify university or private sector firm to assist in development of marker techniques.	92
Compare diffusion rates of selected organic contaminants with microbial degradation rates to determine which is limiting. Initiate development of persistence tests.	93
Develop techniques for investigating sorption sites on and within soil particles. Complete development of persistence tests. Initiate development of activity tests.	94

FUNDING ($K):

FY92	FY93
250	500

RESEARCH ACTIVITY: U.S. Army Engineer Waterways Experiment Station, CEWES-ES-A (Dr. Doug Gunnison) and CEWES-ES-R (Dr. Judy Pennington), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, (601) 634-3873 or (601) 634-2802.

RESEARCH TITLE: In Situ Treatment of JP-5 and Fuel Oil Vapors in Unsaturated Soils

SHORT TITLE: In-situ JP/Diesel Vapor Treatment

OBJECTIVE: Provide the Navy with cost-effective on-site and in-site methods to remove and destroy low volatility fuels, such as JP-5 and marine diesel. The field pilot study at NAS Fallon, which involves a combination of soil venting and in situ bioremediation (bioventing), needs to be completed and designed for a field demonstration at Fallon or other Navy site. Existing technologies for treating vapors removed during soil venting or bioventing are very expensive. Vapor-phase bioreactors are an innovative treatment scheme that could potentially lower vapor treatment costs significantly, while also completely destroying the contaminants. Laboratory-scale research is also required to support the field activities.

APPROACH: Conduct laboratory and field pilot-scale testing of innovative in situ methods for treating, removing and destroying low volatile fuels, which are the Navy's major IR pollution problem. Techniques are currently being field tested include bioventing at NAS Fallon. The main emphasis will be on field evaluation of innovative technologies. Vapor-phase bioreactor development and testing has been planned for use in conjunction with the bioventing research. Several European designs have already been successful, so that major thrust will be to fine-tune existing units to cost-effectively biodegrade JP-5.

BENEFITS: Low volatility fuel contamination of soils from tank leaks and spills is the most important pollution problem in the Navy, in terms of volume. Over 600 IR sites are contaminated, with the principal contaminant being JP-5. Bioventing combines the potential capabilities and low costs of "soil venting" with "enhanced in situ bioremediation" to remove both high and low volatility JP-5 jet fuel components from soils and the groundwater table in situ. Aerobic microorganisms flourish and rapidly degrade the fuel components under the aerated soil conditions promoted by soil venting, provided that the environment is engineered to facilitate the biodegradation (proper moisture, nutrients, etc.). Aerobic biodegradation can mitigate both residual and vapor phase hydrocarbon concentrations, both within the soil profile (bioventing) or after venting to the surface, in a vapor-phase bioreactor. Soil venting of JP-5 and other low volatility fuels at ambient soil temperatures is not cost-effective and would require several years to reach regulated contaminant levels in the soil. Since in situ treatments are the cheapest available and most accepted by the public, methods to promote accelerated venting could prove practice.

A vapor-phase bioreactor could effectively degrade the volatilized JP-5 components from the steam injection/vapor extraction treatment.

PARTNERS AND RELATED ACTIVITIES: Bioventing is being conducted at NAS Fallon in coordination with WESTDIV, NEESA, Tyndall AFB (AFESC), DOE-ORNL, EPA Kerr Laboratory, and Nevada Department of Conservation and Natural Resources.

MILESTONES:

Determine limiting factors for optimization of field environmental conditions in laboratory for bioventing and vapor-phase bioreactor	FY92
Complete laboratory and field respirometric evaluations	FY92
Complete construction and initiate testing of bioventing pilot system at Fallon	FY92
Evaluate existing vapor-phase bioreactors and develop design criteria for high efficiency vapor-phase bioreactor	FY92
Complete bioventing field pilot studies at Fallon	FY93
Bench-scale testing of best bioreactor designs	FY93
Develop best general bioventing methods from Fallon data, and design field demonstration system	FY94
Compile Tech Assessment/User Guide on bioventing	FY94
Pilot-scale testing of best bioreactor at field site	FY94
Compile Tech Transfer Package on vapor-phase bioreactor design, efficiency and use	FY94

FUNDING ($K):

FY92	FY93	FY94	FY95	FY96	TOTAL
600	750	900	600	250	3,100

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RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory, Port Hueneme, CA

OK 93

RESEARCH TITLE: Underground Fuel Steam/Vaccum Removed

OBJECTIVE: The Navy needs an adequate and cost effective engineering solution for remediating soil contaminated with organics, solvents, and hydrocarbons. The main focus is to develop steam injection cum vacuum extraction for remediating soil.

APPROACH: Research and develop the techniques of steam injection and vapor extraction of the hazardous contaminants in the polluted ground. Identify the physical mechanisms significant to the process. Generate design criteria for the process implementation. Test the process at NAS Lemoore with soil conditions consisting of sand and clay types of materials. Show types of soil conditions that enhance this type of process.

BENEFITS: Soil and groundwater contamination by hazardous wastes/materials including oil/fuel leakage from underground storage tanks is a major problem at over 600 IR remedial sites within the Navy. These urgently need a cost-effective technology alternative for clean up. Various forms of this technology have been used and demonstrated under the EPA Site Program. However, the melding together of these two technologies has not been sufficiently examined in the field. The determination of the controlling mechanism would enhance the ability of the user in properly designing a treatment process.

PARTNERS AND RELATED ACTIVITIES: This work is being coordinated with the EPA Risk Reduction Laboratory, the EPA SITE Program, PAD Lemoore and the California Department of Health Services.

MILESTONES:

Complete treatability test and establish pilot plant design criteria.	FY92
Design and fabricate the pilot plant for field testing.	FY93
Initiate first stage clean-up thrust.	FY93
Generate final design specs of the system.	FY93

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
150	100	2,000	2,600	4,850

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA

RESEARCH TITLE: Small Arms Range Remediation

OBJECTIVE: Develop protocols and identify technologies to treat soil at abandoned ranges, to control pollutants at existing ranges, and to integrate pollution controls with civil engineering design requirements at future ranges.

APPROACH: Assess several small arms ranges to determine the type and quantity of pollutants and extent of contamination. Prepare a problem statement to analyze the threats to human health and the environment from contaminants at the sites; develop and analyze concepts for controlling the contamination. Select promising technologies and conduct bench scale evaluations. Conduct field demonstrations on successful technologies and transfer the technology to Navy use.

BENEFITS: Accumulation of lead from bullets in impact berms at small arms caused the soil to be a hazardous waste and nonpoint source pollution. The Navy have identified a requirement for the identification of technologies to treat heavy metal contaminated soil from small arms range target butts to make it non-hazardous and to control sediment and other pollutants from entering surface waters and groundwater. After a period of use, the target butt at the ranges capture so much lead that a ricochet problem forms. The target butt is torn down and a new one is constructed using clean soil. Sieving of the contaminated soil does nothing to reduce soluble lead content of the soil. The nonpoint source pollution initiation decision report identifies impact zones, including target butts, as sources of nonpoint source pollution, which may adversely impact water quality.

PARTNERS AND RELATED ACTIVITIES: NCEL will consult with the Army research laboratory, CERL, which is looking at the Army's requirements for training ranges. NCEL will consult with Bureau of Mines to assess mining techniques that can be used to recover lead from soil. Over the past year NCEL has looked at means for assessing target ranges and completed in-house characterization of three small arms fire target ranges.

MILESTONES:

Develop and evaluate concepts for the control of pollutants at small arms ranges.	FY91
Conduct bench-scale testing and design pilot unit.	FY92
Construct pilot soil treatment unit and field test. Design runoff controls for existing ranges.	FY93
Conduct field demo of run-off control system. Draft design of future ranges. Provide tech transfer package for soil cleanup.	FY94
Provide specifications for future ranges and provide tech transfer for runoff controls.	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
400	600	800	500	3,300

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory; Port Hueneme, CA

RESEARCH TITLE: Heaped Soil Bioreactor

OBJECTIVE: Complete development and provide design criteria for vapor extraction surface-pile soils bioreactor at Navy sites contaminated with low volatility fuels. Develop best overall methodology from site-specific data and compile a protocol.

APPROACH: The proposed work will include development and evaluation of state-of-the-art and new design parameters for a heaped soil bioreactor. Initial research will be augment by the present lab scale studies being done at NCEL. This work will then transition to a field setting for scale-up of heap pile bioreactor.

BENEFITS: Vapor extraction from surface-piled soils contaminated with fuel, especially gasoline, is a common low-cost method to deplete surface soil hydrocarbon concentrations to acceptable levels. However, minimal information exists regarding use of this technology for removing low volatility hydrocarbons, common in jet fuels and diesel, from soils. The heaped soil bioreactor process would avoid expensive external treatment (e.g., carbon sorption or combustion) of vented vapors, since all treatment would take place within the heap pile.

PARTNERS AND RELATED ACTIVITIES: AFESC observed enhanced removal of hydrocarbons from a soil pile venting study. They concluded that biodegration occurred. In FY 89 NCEL conducted a clean-up of diesel fuel on 14,000 cubic yards of piled surface soils. This year NCEL is completing a enclosed surface heaped soil bioreactor where regulatory pressures for release for ozone producing reactants is strictly enforced. The basic design for this latter effort derives from the earlier diesel fuel cleanup.

MILESTONES:

Complete pilot studies field test and design criteria using methodology obtained from lab feasibility/treatability studies.	FY92

FUNDING ($K):

FY92
50

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory, Port Hueneme, CA.

RESEARCH TITLE: Underground Fuel Pump and Treat Demonstration

OBJECTIVE: Evaluate treatment schemes for the removal of contaminants from pump and treat actions. Provide a guidance document for pump and treat operations.

APPROACH: Determine through a ranking procedure candidate chemical treatment technologies for a gasoline spill site. A number of candidate technologies have been shortlisted: thermal vacuum spray combustion, chemical oxidation, air stripping and possibility polishing with carbon. The final technologies will be limited to three. The performance, reliability and implementability of each of these technologies will be determined. Six categories of decision factors will be used for the evaluation. These will include treatment efficiency, adverse impacts, costs, technical feasibility, and external requirements. Trade off analysis will be used to weight the decision factors. Conduct a demonstration test at a gasoline spill site to evaluate candidate technologies.

BENEFITS: Pump and treat is a common remediation technique being employed or planned at several Navy sites. The performance and cost-effectiveness of the technologies used to treat water and vapor pumped from the contaminated groundwater can vary significantly. In use evaluation of selected candidate technologies will provide the performance data needed to determine the best treatment scheme for each contaminated site.

MILESTONES:

Determine candidate treatment technologies	FY92
Determine state requirements for cleanup	FY92
Develop decision factor analysis matrix	FY92
Initiate demonstration test	FY92
Complete test of candidate technologies	FY93
Complete documentation and report	FY93
Provide design guidelines for technology transfer for IR sites	FY93

FUNDING ($K):

FY92	FY93
250	250

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory, Port Hueneme, CA.

RESEARCH TITLE: Coastal Area Capping Technology

OBJECTIVE: The objective of this study is to provide design criteria for industrial operations, landfill cap covers and low level hazardous waste site whose storm water runoff threatens the environment or whose schedule for cleanup has been delayed. Research efforts from this study will be easily translated to the public sector. The study is presently a joint effort with the DOE.

APPROACH: This program will investigate industrial runoff controls and alternative capping technologies for landfills, with possible use at other hazardous waste sites in coastal areas as well. The current EPA guidance does not supply all the necessary information for long term success (>20 years) of landfill caps. The research in this program will identify technologies suitable for areas of high precipitation and in high water table areas common to Navy sites. The proposed site is located in an area of high precipitation in Washington. This new start will investigate Navy industrial operations and landfill sites and begin planning for a field demonstration.

BENEFITS: The Navy is in the process of conducting research to identify runoff impacts and to identify technologies which can clean up our industrial operations and hazardous waste sites. Some of these hazardous waste sites are combined waste landfills that have been capped to varying degrees. In many cases they are producing toxic leachates due to erosion and water penetration through the landfill. Due to technological limitations in the treatment of these combined wastes, an alternative is to cap treatment control runoff or to these waste sites utilizing more advanced technology than when they were originally closed. Problems facing runoff controls include intermittent nature of discharges and salinity from coastal waters. Problems facing capping technology include cap failure, biointrusion, water infiltration and erosion.

PARTNERS AND RELATED ACTIVITIES: This is a joint effort with the DOE and U.S. Army Waterways Experiment Station.

MILESTONES:

Implement field demo; conduct on-site monitoring of Leachate production and runoff.	FY 92
Conduct On-Site Monitoring	FY 93
Complete field test monitoring program	FY 94
Provide technology transfer design package	FY 95

FUNDING ($K):

FY92	FY93	FY94	FY95	Total
200	325	450	450	1,425

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory; Port Hueneme, CA

RESEARCH TITLE: PCB Decontamination using Base Catalyzed Decomposition Processes (BCDP)

SHORT TITLE: Base Catalyzed PCB Decomp

OBJECTIVE: To provide a technological procedure and process for remediating PCB contaminated soils. Incineration is too expensive while landfilling is impractical. Bioremediation of PCBs is not available.

APPROACH: PCB contamination to an estimated 5,500 tons of soil has been identified to be very cost-effective in decontaminating PCB on-site. A scale-up BCDP system has been fabricated for field technology demonstration. The field full scale clean up activity will follow. The standardized process will then be applied at other Navy, DOD and DOE sites.

BENEFITS: There are about 150 Navy sites contaminated with PCB. The application of this technology will reduce treatment costs by ten to one and reduce long-term liability for the Navy. There is great potential for applying this technology to other federal facilities and the private sector.

PARTNERS AND RELATED ACTIVITIES: Development of this technology is presently being coordinated with the EPA Risk Reduction Engineering Laboratory, DOE Pacific Northwest, the Navy's PACDIV, and Public Works Center, Guam. Actual cleanup funding is not reflected in this documentation as the source of such funding is from PACDIV.

MILESTONES:

Design and fabricated a 1-2 ton per hour system for technology demonstration FY'92

Complete PWC Guam site clean up with the scale-up (1-2 ton/hour) system and ship the system to other Navy sites for PCB decontamination (projects). FY'93

FUNDING ($K):

FY92	FY93	TOTAL
200	200	400

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory; Port Hueneme, CA

RESEARCH TITLE: Fuel Contaminated Groundwater Treatment Using Photochemical Oxidation

OBJECTIVE: This program intends to investigate the applicability of photochemical oxidation process to treating groundwater contaminated with fuel and various organic compounds. It will provide the Navy a protocol of how and when to apply the photochemical oxidation processes to site remediation.

APPROACH: Complete literature review of most promising oxidation technologies. These are hydrogen peroxide, ozone, chemical catalysts, ultraviolet light and solar energy. Coordinate site selection with literature review. Characterize site and conduct treatability laboratory investigation. Determine engineering design factors. Design and fabricate pilot plant. Initiate pilot test. Complete test reports. Determine applicability to 500 various Navy sites.

BENEFITS: Contaminated groundwater (GW) exists at many Navy disposal and spill sites. At sites where GW are also the local water supply, there exists a double hazard. Conventional physical/chemical treatment technologies typically deal with low level organics pollutants in water by removing and transferring the pollutants, without destruction, to a different media. These are inefficient processes that do not present a clean solution. Biological technologies also have limitations. Technologies that can remove pollution efficiently and eliminate future environmental liabilities are needed. Photochemical oxidation processes are clean technologies that can present a solution to the Navy's GW contamination problem.

PARTNERS AND RELATED ACTIVITIES: This program is conducted in conjunction with NAEC Lakehurst, N.J.; one of Navy's Engineering Field Division (NORTHDIV); the New Jersey Department of Environmental Protection; U.S. Army Construction Engineering Research Laboratory (CERL); and Illinois State Water Survey in Champaign, Illinois.

MILESTONES:

Conduct field demonstration of photochemical oxidation processes.	FY92
Complete field demonstration test report.	FY92
Prepare technology transfer package.	FY92

FUNDING ($K):

FY92
45

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory, Port Hueneme, CA

RESEARCH TITLE: Petroleum Contaminated Groundwater Treatment by Biological Processes

OBJECTIVE: The objective of this task is to provide a means of biological treatment of aromatic and alkyl hydrocarbons by anaerobic and/or facultative microorganisms in groundwater (brackish and salty water) at a tidally influenced site, where bioventing is not possible due to the high groundwater table, large volume, and the tidal influence. Focus is directed to anaerobic conditions since aerobic conditions for aromatic hydrocarbon biodegradation in groundwater is well characterized.

APPROACH: On-site bioreactors at the site are installed from a previous project at NWS, Seal Beach, CA. It is proposed to use these bioreactors under controlled conditions to determine, parameters need for anaerobic treatment of aromatic hydrocarbons in the groundwater primarily from the leak of an unleaded fuel tank. Once the conditions are determined, a grid of wells will be placed in a test plot (also may be applied at NAEC Lakehurst, N.J.) where remediation of the groundwater in the test plot can be observed and measured, utilizing the knowledge under strictly controlled conditions to that of the grid-well system where conditions are natural. Nutrients may be added as needed, based on the bioreactor optimized conditions.

BENEFITS: The Navy has many coastal sites that have hydrocarbon spills where conditions are similar for the biodegradation of aromatic hydrocarbons dissolved in the groundwater, particularly in the anaerobic zone. Sometimes the spill itself creates an anaerobic zone. Until about 10 years ago, such anaerobic degradation of aromatic hydrocarbons was recognized, but discoveries changed that misconception. This particular project would be at the forefront of such investigations as well as providing a means of biological clean-up in a zone of soil and groundwater which may not be amendable to other types of remediation. That is, due to the tidal fluctuations in the groundwater and due to the high water table, salt content, this type of bioremediation may be ideal for this site and similar Naval sites. Biological treatment at or in similar sites has been shown for aerobic processes to be less expensive than other types of remediation. There are no specific data base and/or application system available for this type of anaerobic biodegradation of aromatic hydrocarbons in groundwater, although it is apparent it will be less expensive due to the ability to leave contaminated soils and groundwater in place.

MILESTONES:

Determine anaerobic biodegradation conditions for the three bioreactors at the site under methanogenic, sulfate-reducing and nitrate reducing states. Prepare interim report.	FY92
Design and install grid-gallery of wells for test plot.	FY93
Perform testing on grid-gallery walls for test plot and prepare final report.	FY94

FUNDING ($K):

FY92	FY93	FY94	TOTAL
320	450	450	1,220

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory, Port Hueneme, California.

RESEARCH TITLE: Slurry Bioreactors for HW Remediation

OBJECTIVE: Develop reactor systems for hazardous waste (HW) remediation based on biological degradation mechanisms. Configure systems for greatest possible control of volatile emissions (VOC), toxic intermediate microbial metabolites, and maximum retention of the active microbes. Provide an efficient, on-site means of monitoring the effectiveness of a bioremediation process at a HW site through rapid analysis of the metabolites and breakdown products. Develop analytical tools to rapidly measure the extent of a hazardous waste site. Produce protocols for effective deployment of bioreactor systems to specific sites where demonstrated procedures can be followed step by step to effect rapid startup and early successful results. Concentrate on major Navy-specific HW, particularly JP-5 and marine diesel fuel (DFM).

APPROACH: Emphasis will be placed on both dig and treat and pump and treat technologies. Initial efforts will focus on determining what the precise state of the art is in the commercial sector and what the most promising emerging technologies seem to offer. This will permit intelligent cost/benefit analyses to be performed. Costs of potential bioreactor approaches can then be more accurately compared to more conventional existing technologies. Following these early comparisons, rigorous attention will be placed on designing reactor procedures that incorporate the best available chemical anlaytics for monitoring HW breakdown progress and best available microbial manipulation procedures for monitoring health and condition of the functional reactor microbes. Pilot scale reactor systems will then be tested first in the laboratory in order to fully debug and optimize all relevant subsystems and procedures. This work will use fresh soils from the selected contaminated site(s). Based on these tests reactor systems will then be deployed to the specific site for on-site pilot remediation demonstration.

BENEFITS: Protocols, both generic and specific, that are developed from this approach will be of value in remediating additional HW sites contaminated with JP-5 and DFM. Cost/benefit analyses can be made more readily based on the results of this task. Technology transfer to other DOD and private sector agencies should be readily facilitated. Further, the knowledge base obtained from this project should provide the necessary insights for reactor bioremediation of other Navy HW such as solvents.

PARTNERS AND RELATED ACTIVITIES: We presently have a collaboration with the EPA Cincinnati and are expanding to include additional EPA colleagues and laboratories. The ready exchange of ideas and technical information is of benefit to both parties. We are in close touch with the personnel at the Air Force Engineering and Services Center and the Army Corps of Engineers Waterways Experiment Station. We consult closely with colleagues at the Naval Civil Engineering Laboratory, and the David Taylor Research Center regarding matters relating to petroleum hydrocarbon remediation.

MILESTONES:

FY92: Initiate careful chemical analytics as it applies to microbial remediation. Begin cost/benefit analyses with comparisons among available bioremediation methods. Begin set-up of suitable toxicity assays for monitoring the various stages of the remediation process. Initiate laboratory pilot scale reactor tests using freshly collected soil from a designated Navy site impacted by JP-5 or DFM. Begin interfacing chemical analytical methods with reactor system.

FY93: Conduct scale-up to a larger pilot bioreactor system for field deployment. Begin confirmation tests using this system of all protocols developed on the smaller lab scale system.

FY94: Carry out full-scale pilot demonstration at the designated Navy site. Convene multi-agency workshop to review the results of the on-site demonstration and make comments. Thoroughly brief members of the local and nearby EFD's on the operation and benefits of the pilot demonstration system. Explore possible applications of this technology to full-scale site remediation, possibly in conjunction with other methods, as suggested by the EFD's.

FY95: Complete all documentation for test procedures and operational protocols pertinent to the demonstrated reactor systems. Include in this an implementation guide for potential users and complete specifications for chemical monitoring systems developed for this application.

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
450	600	600	350	1,800

FUNDING DISTRIBUTION ($M):

Industry	0.20	0.25	0.30	0.20
In-house	0.25	0.35	0.30	0.15

RESEARCH ACTIVITY: U.S. Naval Ocean Systems Center, Environmental Sciences Division, Code 52, San Diego, CA 92152-5000. POC: Dr. George Pickwell: (619) 553-2789; FAX (619) 553-6305.

RESEARCH TITLE: Penetrometer Transition/Validation

OBJECTIVE: To transition and validate through comprehensive field inter-calibrations, a rapid field screening capability for determining subsurface distributions of petroleum hydrocarbons. This project will: (1) Make available technology developed via the DOD Tri-Service Site Characterization and Analysis Penetrometer (SCAPS) program for in situ subsurface measurement of petroleum in soils and groundwater. (2) Generate the data base required to validate with the regulatory community the use of a cone penetrometer equipped with a fiber optic sensor system for rapid subsurface screening of petroleum hydrocarbons at hazardous waste sites. (3) Generate and test detailed specification packages that can be used for additional procurement.

APPROACH: This project will focus exclusively on the transition and validation of penetrometer measurement technology for determination of petroleum products in soils and groundwater. First, specifications for an advanced development system dedicated to measurement of petroleum will be developed based on the SCAPS prototype. From the fabrication of the advanced development model, detailed specifications will be generated and used to develop 1st Article Test Specifications which will be tested in an open procurement process for development of a second system. The second major thrust of this project is the validation of the Navy developed cone penetrometer fiber optic oils sensor. This will be accomplished through rigorous inter-comparisons with other "accepted" methods for subsurface sampling and analysis of petroleum hydrocarbons. Data from specific site demonstrations will then be assembled in a comprehensive data base and presented to the regulatory community in order to establish validity of the methodology and gain regulatory acceptance.

BENEFITS: The direct benefit of this project is an improved and much more rapid and cost effective method of screening hazardous waste sites and leaking tank farms for petroleum in the soil and groundwater. Because the penetrometer system with the fiber optic oils sensor provides much more detailed vertical and horizontal data about the location of subsurface contaminant plumes, the number of monitoring wells required for site investigation should be reduced by 50 to 70%. When the cost of conventional analytics required by conventional monitoring wells is considered, the costs savings associated with using the penetrometer system will be at least 50%. The penetrometer will also provide an efficient method for monitoring the effectiveness of site remediation.

PARTNERS AND RELATED ACTIVITIES: This effort will be closely coordinated with the Army (USATHAMA & WES). This effort is unique in that it is focused exclusively on the transition and validation of the capability for measuring petroleum products (oils) which have been identified as the Navy's most common environmental problems. Army efforts are focusing on extending cone penetrometer sensing technology to other contaminants such as explosives.

MILESTONES:

Complete advanced development model	FY92
Complete validation test plan	FY92
Complete 1st article test specifications	FY93
Complete 1st article test system	FY93
Complete Phase I field validations	FY94
Complete Phase II field validations	FY95
Complete validation data based and EPA acceptance	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
600	750	800	850	3,000

FUNDING DISTRIBUTION ($M):

Industry	0.40	0.30	0.40	0.40
In-house	0.30	0.45	0.40	0.45

REFERENCES:

1990(a) "Development of Innovative Penetrometer Technology for the Detection and Delineation of Contaminated Soils." S.S. Cooper, P.G. Malone, P.W. Lurk and S.H.Lieberman. 14th Annual Army Environmental R&D Symposium. 14-16 November, 1989. Williamsburg, VA. (In Press)

1990(b) "Fiber Optic-Based Chemical Sensors for In Situ Measurement of Metals and Aromatic Organics in Seawater and Soil Samples." Malone and Y. Shimizu. International Congress on Optical Science & Engineering, 12-16 March 1990. The Hague, the Netherlands. (In Press)

1990(c) "In-Situ, Remote Measurement for Laser-Induced Fluorescence Emission Spectra of Aromatic Hydrocarbons in Seawater using Fiber Optic Cables." S.H. Liberman, S.M. Inman and G.A. Theriault. Ocean Sciences Meeting, 12-16 February, 1990. New Orleans, La. (Abstract)

RESEARCH ACTIVITY: Navy; Naval Ocean Systems Center, Environmental Sciences Division, Code 52, San Diego, CA 92152-5000; POC: Dr. Steve Lieberman 619) 553-2778.

RESEARCH TITLE: Penetrometer Chemical Sensors

OBJECTIVE: To expand the chemical sensing capabilities of the cone penetrometer system by developing and enchanting chemical sensors that can be integrated with penetrometer system for in situ screening of contaminants in soils and groundwater at hazardous waste sites. This project will focus on developing a new sensor for chlorinated hydrocarbons and on developing methods for improving the quantification and discrimination of optical based sensors for direct measurement of POL (petroleum-oils and lubricants) in soils.

APPROACH: At present there is only one chemical sensor system that has been integrated with the cone penetrometer system. That system is the Navy developed, fiber optic-based, laser-induced fluorometer system for petroleum products. In order to expand the capabilities of the penetrometer system to other classes of contaminants, other sensors are needed that can be inserted into the ground with the penetrometer. Work proposed under this effort is focused on: (1) developing a new sensor for measurement of chlorinated hydrocarbons and (2) developing an advanced sensor for petroleum hydrocarbons that will have the capability of rapidly discriminating different fuel products and also offer improved quantification of fluorescence signals in the various soil matrices.

The approach for the chlorinated hydrocarbon sensor is to adapt technology presently used for oil well logging and geological soils density and moisture characterization to the determination of chlorinated hydrocarbons. The basis of the proposed method is to use neutron induced gamma-ray spectroscopy to quantify the hydrogen and chlorine content of the soil/groundwater sample. The approach will be to first determine the sensitivity of the system for distinguishing chlorinated hydrocarbons from other possible interference such as saltwater intrusions; then to miniaturize and package a neutron induced gamma-ray spectrometer into a penetrometer probe. The sensor will then be optimized for mapping and measuring chlorinated hydrocarbons the soil matrix.

The developments proposed for the advanced petroleum hydrocarbon sensor will focus on use of time-resolved "multiplexing" of dual excitation energies from the 3rd and 4th harmonics of the Nd:YAG laser as a means of rapidly discriminating different fuel products. A parallel effort will be directed at the improved quantification of fiber optic based fluorescence signals in soil matrices through characterization of environmental parameters associated with the subsurface environment (eg., soil type, soil moisture content, presence of naturally occurring organic matter, etc.).

BENEFITS: The direct benefit of this project is an improved and much more rapid and cost effective method of screening hazardous waste sites for chemical contaminants. Efforts proposed under this project will provide a new capability for rapid subsurface detection of chlorinated hydrocarbons and an improved petroleum hydrocarbon sensor that can rapidly discriminate between different fuel products and offer improved quantification of petroleum hydrocarbon concentrations for individual products. It is estimated that costs for site investigations could be reduced by at least 50% for every contaminant for which a penetrometer chemical sensor is available.

PARTNERS AND RELATED ACTIVITIES: This effort will be closely coordinated with the Army (USATHAMA & WES). This effort is complementary to efforts being proposed by the U.S. Army. Army sensor development efforts have explosives sensors as their number one priority. Because petroleum products are not a high priority, the Army has elected not to invest any more R&D effort in petroleum sensors.

MILESTONES:

Complete prototype chlorinated hydrocarbon sensor	FY92
Complete prototype dual wavelength POL sensor	FY92
Complete analysis of chlorinated hydrocarbon sensitivity	FY93
Complete repackaging of gamma-ray spectrometer	FY93
Complete initial field test of chlorinated hydrocarbon sensor	FY94
Complete integration of chlorinated hydrocarbon sensor with penetrometer	FY94
Complete characterization of POL sensor for environmental parameters	FY93
Complete integration of advanced POL sensor with penetrometer	FY94
Complete field tests of advanced POL sensor	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95
430	600	840	500

FUNDING DISTRIBUTION ($M):

Industry	0.15	0.20	0.25	0.10
In-house	0.28	0.40	0.59	0.40

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1988(a) "Fluorescence-Based Fiber Optic Sensors for Direct Determination of Trace-Transition Metals in Seawater. Trans. Am. Geophysical Union, 69, 1264. (Abstract).

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1989(a) "Pressurized Membrane Indicator System for Fluorogenic-Based Fiber Optic Chemical Sensors." S.M. Inman, E.J. Stromvall and S.H. Lieberman, Anal. Chim. Acta. 217, p. 249.

RESEARCH ACTIVITY: Navy; Naval Ocean Systems Center, Environmental Sciences Division, Code 52, San Diego, CA 92152-5000; POC: Dr. Steve Lieberman 619) 553-2778.

RESEARCH TITLE: Integrated Marine Risk Assessment Methodologies

OBJECTIVE: Develop and demonstrate a fully-integrated environmental risk assessment capability for DoD/Navy aquatic hazardous waste sites using advanced laboratory research and field monitoring strategies. This capability will be used to satisfy existing and evolving regulatory requirements for assessing environmental impact of hazardous waste.

APPROACH: Hazardous waste sites in or adjacent to harbor environments are a serious environmental compliance challenge for DoD/Navy. Traditional monitoring approaches for predicting the environmental consequences of contaminants do not satisfy current regulatory requirements. An urgent need exists for an integrated environmental risk assessment program. The following efforts comprise our approach:

1) Integrated ecological assessment of Navy HW sites on San Diego Bay which involves measuring chemical concentrations, biological response and community structure in the sediment and water column.

2) Validation of contaminant dispersion models. Transition to Navy EFDs to assess environmental impact posed by landfills near Navy Harbors with initial efforts made in San Diego Bay.

3) Assessment of contaminant flux and remediation through use of Benthic Contaminant Flux Sampling Device in harbor benthic environments. Development of standardized sampling protocols for trace metals, PAH's and PCB's and work with the EPA to gain acceptance of this technology.

4) Completion of final stages of multi-year ecological risk assessment demonstration project at NCBC Davisville, RI. Development of standardized methodologies for conducting ecological risk assessments at impacted aquatic sites which supports selections of remedial actions if required.

BENEFITS: Improved ecological risk assessment and prediction methodologies are increasingly needed in the CERCLA RI/FS process at aquatic hazardous waste (HW) sites. Standardized protocols that address actual ecological risk will support and validate remediation decisions, potentially eliminating or reducing costly removal (dredging) actions where no significant biological hazards are defined. New methods and contaminant fats and dispersion models will provide DoD/Navy the tools to collect necessary data to make responsible, cost-effective remediation decisions and establish scientifically defensible cleanup levels.

PARTNERS AND RELATED ACTIVITIES: Cooperative work on protocol development will be conducted with the USEPA Environmental Research Laboratory Narragansett, RI & Newport, OR. The modeling effort will be supported by USGS, Menlo Park and UC San Diego Supercomputing Group. Optimization of benthic flux measurements is suported by Scripps Institue of Oceanography (with funding from NOAA Sea Grant) and Battelle Ocean Sciences, Duxbury, MA.

MILESTONES:

Ecological Assessment of Navy Hazardous Waste Sites on San Diego Bay

Conduct bioassays to screen hazardous waste sites.	FY92
Characterize chemical concentrations and biological populations at impacted sites.	FY93
Assess ecological impact posed by hazardous waste sites.	FY95

Contaminant Dispersal Modeling

Validate hydrodynamic predictions with water current measurements.	FY92
Validate toxicant dispersal and partitioning predications with discrete samples.	FY93
Develop user software package for field division personnel.	FY94

Assessment of Contaminant Flux Across Sediment Boundary

Develop sampling protocols for metal and organic compounds.	FY93
Integrate contaminant flux information into ecological assessments at hazardous waste sites.	FY94

Davisville Risk Assessment

Quantify ecological risk and recommend remediation measures at Davisville.	FY92
Publish standardized protocols for environmental risk assessment.	FY92

FUNDING ($K):

FY92	FY93	FY94	FY95
570	730	600	200

FUNDING DISTRIBUTION ($M):

Industry	0.10	0.15	0.12	0.06
In-house	0.27	0.58	0.48	0.14

RESEARCH ACTIVITY: Navy, Naval Ocean Systems Center, Environmental Sciences Division, Code 52, San Diego, CA 92152-5000; POC: Jeff Grovhoug (619) 553-5475

RESEARCH TITLE: Encapsulated or Immobilized Enzymes and Bacteria for Remediation of Fuel Spills

SHORT TITLE: Microencapsulation

OBJECTIVE: Identify bacteria which break down fuel, and particularly the enzymes which they use for this process. Develop technology to use the bacteria of their enzymes for in situ remediation of fuel spills.

APPROACH: Remediation of fuel spills now often relies on digging up contaminated soil so the hydrocarbons can evaporate. This is slow and expensive, pollutes the atmosphere, and is inappropriate for spills that have seeped down deep into the subsoil. It is known that often naturally occurring bacteria and fungi are able to degrade organic compounds (fuels) which have leaked into the subsoil. The limiting factors on their ability to break down these compounds has been the availability of nutrients and oxygen in the soil to stimulate bacterial growth, and the marginal ability of the bacteria to survive in regions of highly concentrated toxicants. Proper injection techniques for delivery of surfactants to reduce toxic concentrations of waste material and for delivery of nutrients, enzyme systems, oxygen carriers or remediation enhancement materials is needed. Protective encapsulation techniques to improve the survivability of bacteria or enzymes need to be developed for regions where fuel concentrations are too toxic for native bacteria to survive on their own. Bioreactors must be developed to supplement the situ effort: such reactors currently suffer from both low volume rates and poor efficiency. Controlled systems of immobilized enzymes and bacteria can be used for the remediation or recovery of both trapped petroleum and heavy metals. Success in this approach would clean up the ground and groundwater relatively rapidly, without requiring movement of large amounts of earth, and without generating hydrocarbon pollution of the air.

BENEFITS: This approach would have beneficial effects on: (1) Climate: Current remediation often uses evaporation of hydrocarbons into the atmosphere. This would be eliminated. (2) Energy: Current methods of remediation are energy intensive requiring movement of large amounts of earth. Bacterial or enzymatic remediation would avoid this. The technology of bioremediation could be licensed or transferred to industrial firms to use for clean-up efforts directed at their own spill sites, or as a marketable service for cleaning pollution at government or private lands.

In FY92, the encapsulation technology developed by the Naval Research Laboratory for controlled release could be investigated in a joint program with an industrial partner through a Cooperative R&D Agreement (CRADA). Such joint development of bacterial nourishment technology could be started in the near term. The technology of immobilization of enzymes and the protective encapsulation of bacteria would be longer term efforts.

PARTNERS AND RELATED ACTIVITIES: A joint program under ONR auspices has been ongoing at NRL to develop controlled release technologies for antifouling and antifungal coatings for ships, supplies and machinery. NRL under ONT sponsorship has been investigating immobilization of enzymes, antibodies and other proteins for sensor development. NRL has been investigating

immobilization of cells for neural network applications. NRL has an informal agreement with Genecor Co. to collaborate on the encapsulation of enzymes. NRL also has a letter of intent from A.G. Germentor Co. to pursue a CRADA on encapsulation of environmentally active compounds. Industrial firms such as Exxon have done some work on bacterial treatment of oil spills, with particular emphasis on clean-up of the Alaska shoreline. At this time, however, there are no CRADAs for joint federal/private efforts along these lines that we are aware of.

MILESTONES:

Demonstration of encapsulation and preservation of function for enzymes and nutrient systems. Selection and encapsulation of a stable oxygen carrier-lab demonstration of efficiency in simulated subsurface fuel spill of JP-5. Negotiation of CRADA for development of controlled release technology. FY92

Identification of industrial partner to perform field studies of encapsulated enzymes. Identification of genes responsible for production of enzymes useful in fuel spill remediation. Demonstration immobilization of cells of high surface area substrates for bioreaction remediation. FY93

Optimize gene expression in bacteria for production of enzymes for remediation. Demonstrate immobilization of remediation bacteria/enzymes on bioreactor substrate. FY94

Transfer enzyme, bacteria and immobilization technology to industry. FY95

FUNDING ($K):

FY92	FY93	FY94	FY95
300	750	450	300

RESEARCH ACTIVITY: Price/Schultz, (202) 767-3557, Naval Research Laboratory Center for Biomolecular Science and Engineering, Washington, DC 20375-5000

RESEARCH TITLE: Buried Ordnance Detection

OBJECTIVE: Develop and demonstrate prototype instrumentation for surveying land and locating, identifying, and marking buried and concealed ferrous hazardous material.

APPROACH: With sponsorship from Army Corps of Engineers, the Navy EOD Tech Center and the Naval Research Laboratory have conducted an R&D program to identify technology and demonstrate hardware and software for surveying and detection of buried ordnance. In FY90 a proof-of-principle piece of equipment completed development and has demonstrated the capability to accurately detect, locate, and categorize a variety of buried ordnance items in blind tests at two very different prepared test ranges at Naval facilities. There are currently no further development funds supporting this effort. The developed equipment uses an array of cesium vapor magnetometers, on a low magnetic signature vehicle for surveying. Location is monitored and plotted using a remote navigation system. Computerized data acquisition and processing provide a magnetic signature map of the surveyed area. The proof of principle instrumentation performed very well for controlled demonstrations. However, it is inappropriate as prototype equipment. Several technology development issues remain both in hardware and in software sophistication. A large array of magnetometers need to be incorporated. They must be more rugged, less expensive and more maintainable than the current cesium vapor instruments. If three axis fiber optic magnetometers become available they will be incorporated. If not, a system will likely be built around gradiometer systems. An improved low vehicle which is low signature, remotely operated, more rugged, and likely remotely linked by telemetry to a central command center will be developed. Improved computer capability with improved software for interactive real-time navigation, near real-time data reduction, and better graphics will be developed and integrated into the prototype. An improved interactive navigation system with 0.5 meter accuracy and capability to provide positional and vector information sufficient to create a real-time missed area map will be developed.

BENEFITS: There are in excess of twenty million acres of bombing and target ranges under DOD control. Each year a significant fraction (200,000 - 500,000 acres) of these spaces are returned to civilian (private or commercial) use. In the near future it is expected that base closures will significantly increase and expand land returned to civilian control. All of these areas must be surveyed for buried ordnance and other hazardous materials, rendered safe and certified as safe for the intended end use. This is an extremely labor intensive and expensive process, with costs often far exceeding the value of the land. More efficient, effective, and economical means to locate and identify buried ordnance and other ferrous wastes is urgently needed. The instrumentation to be developed here will be capable of surveying 20 acres/day, identifying and marking items as small as grenades on or near surface and 500 lb bombs buried at up to 15 feet. Same day detailed survey maps and target list will be available. The prototype hardware and software will be appropriately documented to allow for direct commercialization at the end of this program.

PARTNERS AND RELATED ACTIVITIES: NRL and NEODTC have been partners in the development of the proof of principle technology. This cooperation has worked well and we propose that it continue. Geocenters Inc. (of Newton Centre, MA) along with other small industrial R&D contractors have supported this effort. We will identify appropriate contractor support for the continued development. Other sponsors for continued development do not currently exist; however, other government agencies including USATHAMA (Edgewood, MD) and DOE (Albuquerque, NM) currently have demonstration projects which they would like to undertake with the existing equipment and are likely government users of a field-worthy prototype. There are a wide range of other government and private sector likely end users of this technology.

MILESTONES:

Choose magnetometer technology for use.	FY92
Specify and procure magnetometers for the prototype.	FY92
Tow vehicle preliminary design and construction.	FY93
Software, preliminary operating system documented final package.	FY95
Computer and peripherals acquisition.	FY93
Navigation system specification acquisition.	FY93
System integration and assembly.	FY94
Prototype demonstration, evaluation surveys, stress tests.	FY94
Complete reports, documentation packages, drawings and conduct user surveys.	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95
400	600	800	800

RESEARCH ACTIVITY: Navy, Naval Research Laboratory, Code 6110, Contact: Dr. J.R. McDonald; 202-767-3340

RESEARCH TITLE: Mineralization of TNT to Innocuous End Products by Microorganisms

SHORT TITLE: Microbial Mineralization of TNT

OBJECTIVE: Provide a protocol for mineralizing TNT and RD to innocuous end products, which include cleavage of the ring structures. This may be done either aerobically or anaerobically.

APPROACH: Update Naval Civil Engineering Laboratory (NCEL) literature search to remain informed of previous and on-going research in the biodegradation of TNT and RDX. Evaluate data and identify critical factors contributing to the biodegradation pathways and rates. An aerobic soil white rot fungus and anaerobic sheep rumen bacterial consortium will be subjected to biodegradability testing. Changes in test environmental conditions and use of enrichment culturing techniques should augment degradation rates. A set of contaminant standards and representative field samples will be subjected to biodegradation enhancement factors. An IFR reporting results of the investigations and applicability of the results to Navy ordnance waste sites will be delivered. Complete a field test at two sites: Bangor and Seal Beach. Document the results and provide technology transfer.

BENEFITS: The Navy has identified 26 ordnance waste disposal sites requiring cleanup. The major media contaminated is soil, with subsequent contamination of water bodies. The only treatment method currently effective is incineration, otherwise excavation and land disposal, neither of which are cost effective for the low levels of ordnance prevalent at Navy sites. A cost effective treatment alternative is bioremediation. Numerous studies have revealed that ordnance compounds such as TNT are biotransformed but not mineralized by a diverse group of microorganims in a number of environments. These microbes generally catalyze nitro group reduction but are not known to cleave the aromatic ring structure. The reduction of nitro groups to amino groups results in a number of metabolites binding to organic materials and in the formation of toxic by-products. An aerobic white rot fungus has been shown to degrade TNT and RDX in initial testing while anaerobic sheep rumen microorganisms appear to completely and rapidly biodegrade TNT. Both of these approaches could result in methods to remediate field sites having low levels of ordnance contamination.

PARTNERS AND RELATED ACTIVITIES: The study would take note of the composting work being done by USATHAMA. NCEL will also consult with DOE's Los Alamos Laboratory and investigate the efforts being conducted by Oregon State University. Work is coordinated with WESTDIV and EPA Kerr lab.

MILESTONES:

Update Literature Search and Data Analysis	FY92
Complete field fungus test at Bangor Site D	FY92
Complete laboratory testing for anaerobic system	FY93
Complete technology documentation for Bangor Test	FY94
Process scale-up of rumen process	FY94
Complete small scale bioreactor test at Seal Beach	FY95
Complete Technology Transfer Protocol for both tests	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
350	350	350	350	1,400

RESEARCH ACTIVITY: Navy; Naval Civil Engineering Laboratory; Port Hueneme, CA

RESEARCH TITLE: Chemical/Photochemical Processes for TNT/RDX Treatment

OBJECTIVE: Provide a protocol for destroying TNT and RDX chemically by way of advanced oxidation processes (AOP). The method will remove the nitro compounds and cleave the ring structure continuing on to the removal of all organic carbon. The process will be applicable both for groundwater and soil.

APPROACH: NCEL has experience in utilizing photochemical processes (ozone, hydrogen peroxide and UV light) in destroying organics in a groundwater medium. The reaction mechanism and the by-product formation for destroying organics by AOP is somewhat understood in that carbonyl, organic acids are formed subsequent to removal of organic carbon. However, the chemical degradation of ordnance compounds is not well understood. The degradation pathways in removing the nitrogen groups and the destruction of the organic ring has never been fully described. Therefore, this project will: Update literature review on chemical degradation pathways. Complete treatability studies for treating groundwater contaminated RDX/TNT. Perform a parallel study for treating soil washings from contaminated soils that have TNT and or RDX present. Identify and evaluate optional process conditions varying oxidant dosages and pH factors. Identify other ingredients in the contaminated water that will affect the process reaction and economics such as: carbonates, metals, etc. Complete pilot plant design. Conduct field test for the best photochemical treatment option. Prepare technology transfer packages for both types of processes which include treating contaminated groundwater and treating contaminated soil washing liquids.

BENEFITS: The Navy has identified 26 ordnance waste disposal sites requiring cleanup. The major media contaminated is soil, with subsequent contamination of waterbodies. The only treatment method currently effective is incineration; alternate methods include excavation and land disposal, neither of which is cost-effective for the low levels of ordnance prevalent at Navy sites. However, DOD has also used carbon adsorption to initially treat the ordnance contaminated water, followed by the incineration of the exhausted carbon. This is a costly alternative that does not solve the problem completely. Conventional physical/chemical treatment technologies typically deal with low level contaminants by removing and transferring the contaminants to another media. Advanced oxidation processes are clean technologies that will present a solution to the Navy's groundwater and soil ordnance contamination problem. AOP will complement biological processes where the latter may not be appropriate.

PARTNERS AND RELATED ACTIVITIES: This study will coordinate with OESO (Ordnance Environmental Support Office) and work being conducted by USATHAMA. The latter are conducting demonstrations of soil contaminated with ordnance only.

MILESTONES:

Update Literature Search	FY92
Complete Treatability Tests for Groundwater	FY92
Complete Treatability Tests for Soil Washing Process	FY93
Complete Design for Pilot Units	FY93
Complete Field Demonstration of Groundwater Pilot Unit	FY93
Complete Soil Washing Field Pilot Unit Tests	FY94
Provide Process Scale-up of GW Unit	FY94
Provide Process Scale-up Soil Unit	FY95
Complete Technology Transfer Packages	FY95

FUNDING ($K):

	FY92	FY93	FY94	FY95
Groundwater Treatment Unit	200	0.800	0.500	0.200
Soil Washing Treatment Unit	100	0.600	0.900	0.400
TOTAL	300	1.400	1.400	0.600

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043 (805) 98201353 DSN 551-1353

RESEARCH TITLE: Biodegradation of Nitrate Esters

OBJECTIVE: To develop and demonstrate processes for biological degradation of nitrate esters. The data gathered could be used as the design basis for full scale processes to remove nitrate esters from contaminated wastewaters.

APPROACH: The investigation will be conducted in two phases. One phase will look at work completed to this date on the biodegradation of nitrate esters and isolating a mintrate ester specific organism. This work will be continued to develop a nitrate ester specific bug and to define the physical parameters required to maximize the degradation of nitrate esters. The second phase, after defining the parameters for operating the system, will be to test different wastewater streams on a bench scale pilot plant. The final step will be to pilot a 1,500 gallon batch process using these parameters.

BENEFITS: This technology has broad application for the entire ordnance community and may lead to a cost effective organic alternative to site remediation.

PARTNERS AND RELATED ACTIVITIES: University of Cincinnati and University of Maryland.

MILESTONES:

Develop biofilter and enzyme technology at bench scale.	FY92
Design and construct pilot plant.	FY93
Conduct pilot scale demonstration.	FY94

FUNDING ($K):

FY92	FY93	FY94
350	400	200

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206

RESEARCH TITLE: Characterization of Decomposition of Nitrate Esters

OBJECTIVE: To identify the intermediate reaction products of nitrate ester destruction and compare with the predicted products. Verify on a laboratory scale the intermediate products of decompositionand the intermediate reaction of nitrate ester destruction and compare with the predicted products. Verify on a laboratory scale the intermediate products of decomposition. The intermediate reaction products are not well known. In order to qualify any process as environmentally benign, it is necessary to determine these reaction products and to quantify their existence.

APPROACH: Work will be performed at the laboratory scale by first conducting theoretical studies to identify possible intermediate reaction products. The next work area will be to treat a waste stream containing nitrate esters in an ionizing radiation source to determine the chemical composition of the reaction process.

BENEFITS: This project will allow facilities to maintain operational readiness by resolving the environmental problems associated with propellant/explosive processing. If a technology is not developed that will minimize explosive contaminants in wastestreams, the facilities will be out of EPA compliance and face the real threat of shutting down until in compliance.

PARTNERS AND RELATED ACTIVITIES: University of Maryland for basic research.

MILESTONES:

FY93 Phase 1--Theoretical study of nitroglycerin decomposition reactions.
Phase 2--Verification of intermediate product existence.

FY94 Phase 1--Theoretical study of decomposition of TMETN, and Otto Fuel.
Phase 2--Verification of intermediate products.

FY95 Construct pilot scale demonstration unit.

FUNDING ($K):

FY92	FY93	FY94	FY95
100	150	165	250

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640; R.E. Garcia, Code 280P2, Phone (301) 713-4206

RESEARCH TITLE: Range PEP Decontamination

OBJECTIVE: The objectives of this project are:

1. To evaluate feasibility of the existing technologies for remediation of any selected site.

2. Review the emerging technologies and study their applicability for the remediation needs.

3. Study the applicable regulatory requirements, if any, of RCRA, SARA, and NPDES affecting the use of selected technology.

4. Provide a concise and comprehensive information package to the policy and decision makers about the broad and complicated issues of range remediation.

APPROACH: Detection, identification and remediation of ordnance and leached chemicals from ordnance in abandoned ranges is not a simple task, especially when many of the technologies are still under the development stage. It is a highly labor and capital intensive operation.

The program, in a broad sense (after the preliminary investigation), is divided into three main stages, assuming that the sites have been already identified:

1. Evaluate the candidate technology and related issues for the selected site.

2. Study the historical evidence of any unexploded hardware or any other contamination.

3. Identify applicable regulatory requirements for the use of technology and the site remediation.

BENEFITS: Range remediation is required for current and future Naval base closings to reduce the Navy's liability.

PARTNERS AND RELATED ACTIVITIES: Naval Explosive Ordnance Disposal Technology Center

MILESTONES:

FY92/93 Demonstrate emerging remediation technologies.
FY94 Evaluate new technologies for range remediation.

FUNDING ($K):

FY92	FY93	FY94
150	515	250

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206

RESEARCH TITLE: Mobile Utility Support Equipment (MUSE) NOx Emissions Reduction

OBJECTIVE: Test and evaluate developing technologies for reducing NOx emissions on Navy MUSE equipment.

APPROACH: Increasingly stringent environmental laws governing emissions from combustion devices is making it very difficult for the Navy to operate its Mobile Utility Support Equipment (MUSE). MUSE equipment includes self-contained packaged boilers, diesel generators and gas turbine generator sets that are shipped worldwide to provide temporary utility service for military organizations. The air quality regulations that most seriously affect MUSE operation are those addressing oxides of nitrogen (NOx). Technologies for bringing Navy MUSE units into compliance with existing and projected NOx emission regulations will be developed. Selected technologies will be tested to determine actual emissions reduction. Finally, procurement specifications will be prepared for equipment, materials and procedures that will bring MUSE units into compliance with current and anticipated environmental regulations.

BENEFITS: Successful testing will lead to new technologies capable of bringing Navy MUSE units into compliance with new air pollution regulations. These same technologies will be useful for industrial applications.

PARTNERS AND RELATED ACTIVITIES: Several government organizations and industrial concerns are cooperating in this study. These include: NEESA, CBC Port Hueneme, NAS Point Mugu, Solar Turbans, Cummins Diesel, and the South Coast Air Quality Management District (Los Angeles).

MILESTONES:

Perform lab and field tests to determine NOx emission regulations	FY92
Prepare specifications and implementation plans	FY92-94

FUNDING ($K):

FY92	FY93	FY94
400	900	900

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, (805) 982-1353 AV 551-1353

RESEARCH TITLE: Leak Detection System for Large Underground Fuel Storage Tanks and Pipelines

OBJECTIVE: To provide a leak detection system for the Navy's 20-million-gallon underground storage tanks at Redhills and develop pipeline leak detection using in-situ hydrocarbon sensors.

APPROACH: Perform assessment of measurement technologies, sensors, and concepts applicable for JP-5 pipelines and large USTs for accurate and precise measurement of product quantities. Select alternative(s) such as real time MOS hydrocarbon sensors for JP-5 pipelines techniques based on fuel mass measurements that are not influenced by temperature and can be potentially applied to Red Hill tanks. Conduct laboratory and field scale evaluation studies to determine design parameters such as sensor spacing for pipelines and to develop fuel level measurement technique that are not affected by product variations, temperature fluctuation, and require minimal human interface.

BENEFITS: The level measurement and inventory procedures for leak detection from large USTs are inherently inaccurate due to (a) product stratification, (b) temperature fluctuation in the stored products, (c) large volumes of fuel, and (d) errors introduced by human interactions for temperature and specific gravity measurements. For large tanks, these inaccuracies result in significant errors in fuel inventory determinations and these measurements can not be relied upon for leak detection purposes. The Red Hill Navy Supply center facility in HI, maintains 20 large USTs; each tank is about 250 ft high, 100 ft in diameter and holds about 20 million gallons of fuel. The fuel farm is located on top of island's water supply aquifer. Undetected fuel leaks can potentially contaminate the aquifer. This threat places the Red Hill facility under close scrutiny of environmental regulatory agencies. The current tank monitoring system can not distinguish tank level changes caused by leaks and level changes caused by temperature fluctuations. At NAS Lemoore, a fuel leak was found in the 16" dia, 1800 ft long JP-5. By the time the leak was found, the product plume had spread over more than three acres. The routine fuel delivery measurements were not able to discover the gradual fuel loss. An early warning warning system applicable for large pipelines can avoid excessive product loss and subsequent cleanup. No commercial system is available to provide the required leak detection capability for these very large tanks. The installation of a leak detection system would provide benefits to other Navy locations. The Navy has over 500 large USTs ranging in size from 50 thousand gallons to one million gallons for which no technology exists.

PARTNERS AND RELATED ACTIVITIES: NCEL will consult with the EPA EMSL laboratory at Las Vegas.

MILESTONES:

Initiate laboratory scale evaluation of selected techniques for large tanks and T&E full scale pipeline network system.	FY92
Prepare user data package for pipeline sensor technology transfer.	FY93
Install a system in one of the Red Hill tanks and conduct operational T&E. Determine RAM, ILS, safety characteristics and operational integration requirements.	FY94
Provide a procurement document/technology transfer package to enable tank retrofit.	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
500	900	700	150	2,250

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory; Port Hueneme, CA

RESEARCH TITLE: Oxygen Breathing Apparatus Canister Disposal

OBJECTIVE: Develop a process and machine which will dispose of used oxygen breathing apparatus canisters in environmentally acceptable manner. Oxygen breathing apparatus (OBA) canisters are primarily used by Navy firefighters, especially aboard ships where firefighters are required to enter smoke-filled or oxygen deficient compartments. OBA canisters contain significant amounts of barium and must be disposed of as hazardous waste.

APPROACH: Develop a machine that will open spent or discarded OBA canisters; shake, scrub or wash out the contents, and completely rinse the canister. The spent chemicals and rinse water will be captured and treated with acid to. precipitate the barium as an insoluble barium salt. Barium will be filtered from the wastewater and disposed of as a hazardous waste. The wastewater can be disposed of by discharge into a sanitary sewer system. The steel canister can be recycled as scrap metal.

BENEFITS: The disposal of used OBA canisters is a major hazardous waste management problem for Naval Training centers. Tens of thousands of canisters must be disposed of, each by contract at a cost of $8 to $10 each. At the present time, spent canisters are disposed of by burial at hazardous waste dump sites. A liability problem exists if barium and potassium from these buried canisters escape from the dump site and contaminate soil or water. The proposed system recovers barium and other metal salts from the spent canisters for recycling. The technology will be available for transfer to Training Centers in two years.

PARTNERS AND RELATED ACTIVITIES: This work will be performed in coordination with the Naval Training Centers.

MILESTONES:

Construct and test prototype unit.	FY92
Refine design and construct final design.	FY93
Transition to operational use.	FY93

FUNDING ($K):

FY92	FY93
145	355

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA 94043

RESEARCH TITLE: Lithium Battery Disposal as Reactive Hazardous Waste

OBJECTIVE: Develop a completely permitted shoreside lithium battery treatment facility to process the majority of the Navy's expended lithium batteries as reactive hazardous waste.

APPROACH:

1.) Assess the magnitude of lithium battery storage, handling, transportation, and disposal problems at all major Navy facilities and generate interim Navy Policy.

2.) Develop "bench scale" neutralization technology at NWSC, Crane, Indiana and assess the suitability of this technology for "scale-up" to meet Navy needs.

3.) Design, fabricate, and acquire DOT approval for a container to be used for transporting "immediately hazardous" lithium batteries.

4.) Design and construct a "full scale" lithium battery treatment technology that will process the current levels of lithium batteries and that meets the local and federal regulations for a technology of this type.

5.) Assess other Naval activities and locations for suitability of treatment sites.

6.) Generate final training, operational manuals and Navy Policy based on the magnitude of the lithium battery disposal problem and the type of neutralization technology developed.

BENEFITS: Commercial facilities can only take very small batteries and there is currently only one commercial facility. Larger batteries are often detonated or simply jettisoned overboard (at sea) because no other disposal mechanism exists. There are many lithium batteries currently in storage at Navy activities because there is no disposal process. This is a major storage and disposal problem. In addition, new air pollution legislation will eliminate open detonation as a means of disposal. Public concerns of water pollution could eliminate "jettison overboard" as a disposal method in the near future.

PARTNERS AND RELATED ACTIVITIES: Currently no one else is addressing this issue. Several private companies have indicated interest in helping with the development/implementation of this project. The efforts of these companies will be incorporated into the project.

MILESTONES:

Tech assessment/Define problem/Develop interim policy	FY92
Develop and test "bench scale" neutralization technology/Submit, revise, and finalize interim policy	FY93
Develop and test shipping container	FY93
Design, build, and test full scale "pilot" neutralization technology	FY95
Assess suitability of various locations for treatment facilities	FY95
Submit final Navy policy, training and operational manuals	FY95

Note: 1. S-start C-complete
2. Quarterly progress reports shall be submitted throughout the duration of the task.

FUNDING ($K):

FY92	FY93	FY94	FY95
100	900	950	900

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: M.A. Lateulere, Code 2730F, Phone (301) 743-4635.

RESEARCH TITLE: Propellant Ingredient Extraction

OBJECTIVE: To design and construct a pilot plant for recovering explosive ingredients from propellants. The pilot plant will have the capacity and the versatility to extract explosive components from many of DOD's explosive hazardous wastes. It will serve as a basis for the design of large scale reclamation operations. Double base propellent ingredients will be recovered using a combination of supercritical fluid extraction and chelation.

APPROACH: Purchase and install supercritical extraction equipment. Demonstrate nitroglycerin recovery and the removal of lead and copper. Evaluate the feasibility of extraction recovery for recycling ingredients.

BENEFITS: Treaty obligations require demilitarizing ICBMs causing Clean Air conflicts. Propellant reclamation techniques could be used to avoid static firing, and OB/OD.

PARTNERS AND RELATED ACTIVITIES: The Naval Weapons Support Center at Crane, Indiana, has contracted with the University of Missouri, Rolla, to reclaim materials from the WOMBAT process. Also Aerojet and Thiokol have developed a similar process for composite propellant for large rocket motors. The work at Indian Head will build on the work done by the Naval Surface Warfare Center and concentrate on double-base propellants.

MILESTONES:

Assemble pilot plant.	FY92
Demonstrate recovery of nitroglycerin and removal of lead and copper.	FY93
Demonstrate feasibility of extraction processing of various propellants and explosives for recycling ingredients.	FY94

FUNDING ($K):

FY92	FY93	FY94
100	315	100

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206.

RESEARCH TITLE: Solventless Processing of Magnesium Teflon Viton (MTV) and Magnesium-Teflon-Hytemp (MTH) Pyrotechnics

OBJECTIVE: Current MTV and MTH compositions are manufactured using large amounts of acetone and hexan solvents as processing aids. Presently 55 gallons of solvent are needed to process 25 pounds of material. The current method is hazardous and expensive, a safety hazard, and presents an environmental problem upon disposal. The objective of this project is to develop a solventless processing method for MTV and MTH compositions.

APPROACH: Combine teflon or hytemp in their latex form. After drying the material, blend the magnesium powder into the mixture. The blend can then be extruded or pressed into its final configuration. Test the product produced by the new process to the existing specification.

BENEFITS: It will reduce the use and emission of Volatile Organic Compounds (VOCs) into the atmosphere. If funds are not invested in a process improvement, then the Navy will need to invest in air cleaning and scrubbing (end of pipe treatment) equipment in order to reduce the emission of VOCs to the atmosphere.

PARTNERS AND RELATED ACTIVITIES: None.

MILESTONES:

Consultation with private industry to determine process parameters and equipment requirements. Inert stimulants will be processed.	FY92
Procurement of pilot scale equipment. Manufacture small batches of MTV and MTH using solventless technique.	FY93

FUNDING ($K):

FY92	FY93	FY94
150	300	100

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: M.A. Lateulere, Code 2730F, Phone (301) 743-4635.

RESEARCH TITLE: Explosive Waste as Fuel

OBJECTIVE: To develop and demonstrate innovative technologies by dissolving propellant and pyrotechnic materials in a solvent, combining the solution with fuel oil, and using the mixture as fuel for a steam-generating boiler. The project will demonstrate the feasibility of using such a system to reduce hazardous waste disposal costs and to recover energy from waste energetic material. The success of the project will be determined by ease and economy operation, and by demonstration of minimal environmental impact.

APPROACH: The demonstration boiler unit is currently installed at Hawthorne Army Ammunition Plant (HWAAP). This project will begin with the disassembly of the existing system and its transportation to the Naval Ordnance Station. Then, the system will be installed and proven out by the installation contractor to verify its operation with Fuel Oil #2. Tests then will begin to use solutions of energetic materials in combination with Fuel Oil #2 to fire the boiler. Stack emissions will be monitored to measure potential environmental impact. Also, process variables will be studied in an attempt to achieve a 99.9% destruction and removal efficiency (DRE) for the energetic material.

BENEFITS: Will help meet DoD-wide need to dispose of energetic waste and to conserve energy. If this research is not done, DoD potentially could have no legal method of disposal upon expiration of current permits. This could drastically effect ordnance production and defense preparedness. This technology would be very easy to transfer to the private sector. Boiler modification would be minimal and only the fuel system would require significant capital investment.

PARTNERS AND RELATED ACTIVITIES: The project is in full cooperation of the U.S. Army Toxic and Hazardous Materials Agency. The Tennessee Valley Authoritiy's National Fertilizer Institute, Mussell Schools, Alabama, is doing preliminary work on slurring the waste propellant with the boiler fuel.

MILESTONES:

A&E Design/Site Preparation Award	FY91
Site Preparation Complete (Army releases boiler)	FY92
Boiler Delivery	FY93
Begin Boiler Tests	FY94

FUNDING ($K):

FY92	FY93	FY94	FY95	FY96
100	483	215	150	95

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206

RESEARCH TITLE: Propellant Recycling

OBJECTIVE: Develop and demonstrate procedures for recycling double base propellant scrap.

APPROACH: The Army and Navy will form a joint DoD effort to minimize propellant waste from double-base extruded grains. The Navy will research the problem of shipping shavings in a safe and easily processed form. The Army will monitor and analyze the quality of grains containing the recycled material to determine rework limits.

BENEFITS: If developed, this technology will significantly reduce the amount of waste propellant burned. It will reduce the amount of waste propellant burned. It will reduce the frequency of open burning operations. It is also the simplest technology and will be significantly cheaper to install and operate than other pollution prevention technologies.

PARTNERS AND RELATED ACTIVITIES: This work is being coordinated with the Radford Army Ammunition Plant (RAAP). They supply the raw propellant. RAAP is looking at a slightly different technology which will be used only by RAAP. The technology developed by Indian Head will be transferable to any rocket motor manufacturer.

MILESTONES:

Install grinding equipment and prove out	FY92
Conduct tests on a variety of propellants	FY93

FUNDING ($K):

FY92	FY93
200	150

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206

RESEARCH TITLE: Ultraviolet Destruction of Nitrate Esters

OBJECTIVE:

a. Purchase and install a UV (ultraviolet light)/oxidation wastewater treatment system for treatment of nitroglycerin and nitrate ester contaminated wastewater.
b. Study the kinetics and mechanisms of nitrate ester decomposition for UV/oxidation treatment.
c. Perform pilot-scale treatability and operate on-site demonstration unit at the actual wastewater discharges. This study is to verify the effectiveness of the treatment and determine more accurate operating requirements.

APPROACH: Our approach began by performing treatability and on-site demonstration studies on samples of each wastewater stream. When effective treatment techniques are determined, a demonstration unit will be operated on-site at the actual wastewater discharges. This study is to verify the effectiveness of the treatment and determine more accurate operating requirements.

BENEFITS: This project will allow facilities to maintain operational readiness by resolving the environmental problems associated with propellant/explosive processing. If a technology is not developed that will minimize explosive contaminants in wastestreams, the facilities will be out of EPA compliance and face the real threat of shutting down until in compliance. This would negatively impact readiness of the fleet.

PARTNERS AND RELATED ACTIVITIES: Solar Chem Inc., for wastewater treatment unit. U.S. Army, PBMA is cosponsor for VOC removal in air systems.

MILESTONES: Demonstration studies were performed in mid FY91, with contractor selection by early fall. The contract for the purchase of the system will be awarded in early FY92. Companies have estimated two months for construction. Installation should be complete by the end of the FY92. Demonstration to start in FY93.

FUNDING ($K):

FY92	FY93	FY94	FY95
300	500	500	300

RESEARCH ACTIVITY: Naval Ordnance Station, Indian Head, Maryland 20640: R.E. Garcia, Code 280P2, Phone (301) 743-4206

RESEARCH TITLE: Pyrotechnic Dye Incinerator

OBJECTIVE: To develop a Controlled Air Incinerator (CAI) to effectively destruct pyrotechnic smokes and dyes with instrumentation to continuously monitor trace metals and polynuclear aromatic hydrocarbons (PAHs).

APPROACH: DoD is currently trying to reduce or eliminate open burning operations, especially for pyrotechnic materials. Open burning causes significant air and ground pollution. The design of the CAI shows promise for complete destruction of the toxic organics with efficient scrubbing of the particulates and metals formed during the combustion process. Testing is required to demonstrate compliance of the prototype unit with RCRA Hazardous Waste Incinerator and Clean Air Act Standards. During FY91 installation and check-out of the CAI was completed by Los Alamos National Labs (LANL) to the point of firing the burners with the following planned schedule:

FY92. Determine location to accomplish environmental testing of the CAI. Perform final check-out and perform emission testing of the unit with simulated Navy colored smoke formulation including testing with NWC China Lake developed PAH monitor. Complete development of Air-ICP Spectrometer for real-time metals in air monitoring of stack gases. Prepare final report on colored smoke test.

FY93. Prepare final report Air-ICP unit. Evaluate CAI System with colored flare material and/or solvents contaminated with pyrotechnic compositions while evaluating the Air-ICP unit on line. Initiate development of FTIR unit for continuous monitoring of air toxic compounds.

FY94. Prepare final report on colored flare/contaminated solvents testing. Complete development of FTIR unit. Initiate design of production unit for processing of pyrotechnic scrap and obsolete Navy smokes and flares.

BENEFITS: Successful implementation will reduce open burning emissions and allow the Navy to dispose of pyrotechnic scrap and smokes/flares in an environmentally acceptable manner.

PARTNERS AND RELATED ACTIVITIES: NWSC Crane will be working with LANL and NWC China Lake.

FUNDING ($K):

FY92	FY93	FY94
250	700	500

RESEARCH ACTIVITY: Naval Weapons Support Center, Crane, Indiana Code 50222 Dan Burch (AV 482-3505) or Russ Thies (AV 482-5584

RESEARCH TITLE: Bilge Waste Treatment System

OBJECTIVE: Develop a shipboard bilge waste treatment system which will provide an effluent which meets existing and anticipated environmental regulations for overboard discharge of oil, heavy metals, and other contaminants.

APPROACH: Navy shipboard oil/water separators are designed to separate oil from water and produce an effluent which contains less than 20 parts per million oil. However, they do not meet the stringent effluent water quality requirements being imposed on ships by the Clean Water Act and state, national and international regulations. These requirements place strict limitations on heavy metals and other EPA priority pollutants discharged into natural water - even in ultratrace concentrations. By the year 2000, effluent quality requirements are expected to equal water quality requirements.

This project will result in shipboard equipment which will process bilge waste and provide an overboard discharge which meets existing and future requirements for all regulated constituents. The treatment system will be designed with inherent flexibility to accommodate the bilge generation levels, and thereby the bilge processing requirements, of all Navy ships.

Existing technologies for the treatment of bilge oily waste will be evaluated to provide a data base from which to select the best technology for meeting the particular and unique requirements of Navy shipboard equipment. In the absence of appropriate existing technology, state-of-the-art technologies/systems will be developed. The existing parallel-plate OWS technology on Navy ships is recognized as an excellent primary treatment stage. Therefore, emphasis will be placed on technologies and systems for secondary and tertiary treatment, as required. Conceptual treatment systems based on the most promising technologies will be developed, and breadboard models will be evaluated in the laboratory. Prototype shipboard bilge treatment systems, based on technologies culled from laboratory evaluations, will be designed and then evaluated aboard ship. Based on the results of these exploratory evaluations, the definitive system will be selected, fabricated and installed for a comprehensive SHIPEVAL. Complete system design, installation and maintenance documentation will also be developed.

BENEFITS: The shipboard bilge waste treatment system will ensure that Navy ships meet all existing and anticipated environmental requirements concerning the overboard discharge of all potential contaminants. The alternative, i.e., the inability of Navy vessels to discharge "pollutant free" waste streams overboard, could potentially limit or even preclude the deployment of these vessels in territorial waters of the United States or foreign countries. Such limits on Naval operations are not acceptable.

The technology development and systems engineering necessary for the discharge of "pollutant free" effluent from Navy ships can be transitioned for use aboard foreign naval vessels and by the domestic and international maritime industry as well. The overall positive effect is significant. The effects of heavy metals and other pollutants on the marine environment are virulent,

destroying marine organisms and, concurrently, the economy of the affected region.

PARTNERS AND RELATED ACTIVITIES: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA. Technology developed and lessons learned in the Small Craft Bilge Treatment Systems program and in the development of a bilge waste treatment system for the Naval Weapons Station (NWS) Earle will be utilized and refined in this effort.

MILESTONES:

FY92: Develop breadboard models based on promising technologies and evaluate in the laboratory.

FY93: Develop prototype systems based on results of laboratory evaluations and evaluate aboard ship.

FY94: Design and fabricate definitive shipboard bilge waste treatment system. Install aboard ship and initiate comprehensive evaluation.

FY95: Complete shipboard evaluation of definitive bilge waste treatment system. Complete design, installation and maintenance documentation.

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
400	400	300	100	1,200

RESEARCH ACTIVITY: David Taylor Research Center, Code 2834, Annapolis, MD 21402-5000. Mr. Ray Schmitt, (301) 267-2578.

RESEARCH TITLE: Hazardous Material Shelflife Extension

OBJECTIVE: Develop recommendations leading to the extension or elimination of shelflife terms for materials in the Navy supply system regarded as potentially hazardous, including the delisting of any disposed overage items that are not actually hazardous. Effort will concentrate on hazardous materials listed in the Ship Hazardous Material List and materials used in rework of Naval aircraft.

APPROACH: An inventory of the major hazardous materials will be prepared and organized into specialized categories based on product characteristics and their criticality to user mission roles and the associated use-profiles. Specification data will be simultaneously gathered from the generator activities. The data will be screened and compared with published (particularly computerized data base) technical information describing the stability and degradation potential of products of the same or very similar type. Conclusions will then be developed as to the appropriateness of the specification shelf terms and the associated storage and use parameters. Recommendations will be organized into three classifications: (1) endorsement of existing specifications, (2) challenge of existing specifications recommending relaxation of requirements; and (3) recommendation of RDT&E projects for evaluating properties of those materials for which inadequate data exist from which to establish specification requirements.

BENEFITS: Many materials are classified as hazardous wastes as a result of shelflife specifications that are of uncertain reliability. In the interest of hazardous waste minimization, the Navy needs to review the adequacy, particularly the possible excessive conservatism, of shelf-life terms of the major environmentally significant commodities in our supply system. At some Public Works Centers, the majority of the hazardous material consigned to disposal is unopened containers of "expired" materials off-loaded from ships. The potential savings is estimated to be many millions of dollars.

PARTNERS AND RELATED ACTIVITIES: This effort will be coordinated with NAVSUP, DLA, and GSA.

MILESTONES:

Analyze and correlate data on shelflife	FY92
Report recommendations	FY93

FUNDING ($K):

FY92	FY93
200	468

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory Port Hueneme, CA 93043 (805) 982-1353 AV 551-1353

RESEARCH TITLE: Hazardous Material Control Technologies

OBJECTIVE: Provide readily accessible information on nonhazardous substitute materials and technologies to Navy users.

APPROACH: Identify Navy hazardous waste streams. Identify the hazardous materials that cause the hazardous waste streams. Research and identify existing less hazardous or nonhazardous substitutes for applicable hazardous materials. Identify hazardous materials that have no existing less hazardous for non hazardous substitutes. Research and develop non hazardous or less hazardous substitutes where none exist. Identify wastes that can be treated or recycled. Identify wastes that cannot be treated or recycled. Research, consolidate, and publish existing treatment and recycle procedures for applicable materials and wastes. Research and develop treatment and recycle procedures for materials and wastes that have no existing procedures. Develop Navy-wide data access system to distribute substitution, treatment and recycle information to all Navy shore and afloat activities in a timely manner.

BENEFITS: The project will reduce both the quantity of hazardous waste generated by the Navy and the degree of risk associated with hazardous materials and wastes. Every Navy activity will benefit from reduced risk and reduced disposal costs. The environment will have less waste to absorb. The Navy will be able to better track hazardous waste reduction efforts and be able to show specific gains where none existed before. It will centralize our attack on the life cycle of hazardous materials.

PARTNERS AND RELATED ACTIVITIES: Navy laboratories, contractors, Systems Commands, and all field activities.

MILESTONES:

FY92 Identify major hazardous waste streams.
Identify materials that result in waste streams.
Identify existing substitutes.
Identify materials that require R&D.
Begin R&D to find substitute materials.
Identify wastes that can be treated or recycled.
Identify waste that cannot be treated or recycled.

FY93 Continue substitution, treatment, and recycle R&D.
Publish data on known substitution, treatment, and recycle procedures.
Develop Navy-wide system that can store known substitution, treatment, and recycle information and be accessed as needed by all Navy activities.

FY94 Continue R&D and information distribution.
Implement information access system Navy-wide.

FUNDING ($K):

FY92	FY93	FY94	FY95
400	500	500	500

RESEARCH ACTIVITY: Commander, Navy Supply Systems Command, Code 0623, Washington, DC 203760-5000, Telephone: (703) 607-0031

RESEARCH TITLE: Ship Paint Reformulation

OBJECTIVE: In support of the Chief of Naval Operations waste reduction goals, as well as proactive compliance with air pollution regulations on volatile organic compounds (VOCs), paint reformulation of Navy paints and coatings will successfully reduce the amount of hazardous waste generated by the Navy.

APPROACH: Determine which paints currently used by the Navy contain hazardous materials and/or do not meet air pollution (VOC) regulations through review of NAVSEA equipment specifications, drawings, standards, etc. Prioritize paints in terms of impact to Navy mission. Reformulate paints where feasible and practical, while stimulating paint suppliers and industry to develop/improve high performance, low VOC, nonhazardous paints and coatings alternatives. QA proposed compliant paints, ship test and evaluate to ensure equal or improved performance. Revise identified specifications and prepare documentation for trade name products.

BENEFITS: This is the only cost-effective approach to solving the VOC compliance issue while eliminating toxic, hazardous materials as opposed to the installation of expensive VOC emission collection and/or post release destruction equipment and treatment of removal/disposal hazardous paint debris. It allows uninterrupted manufacture of needed equipment and reduction of occupational health and safety problems.

PARTNERS AND RELATED ACTIVITIES: Identification, reformulation, and revision of paint specifications will be performed in-house with contractor support in coordination with paint manufacturers. Quality Assurance testing and shipboard application of reformulated and/or new experimental paints will be performed by various Naval Shipyard facilities, leading to the eventual implementation of new, nonhazardous, VOC compliant materials into the fleet.

MILESTONES:

Identification of toxic, hazardous, VOC noncompliant paint specifications

Reformulation, procurement, QA, and shipboard application of paints

Test evaluation, spec. modification, NAVMEDCOM approval, fleet implementation

FUNDING ($K):

FY92	FY93	TOTAL
500	400	900

RESEARCH ACTIVITY: Commander, Navy Supply Systems Command, Code 0623, Washington, DC 203760-5000, Telephone: (703) 607-0031

RESEARCH TITLE: Ship Abrasive Blast Recycling

OBJECTIVE: Build and demonstrate a sloped-grid, fluidized bed, spent abrasive processing and recycling plant at Mare Island Naval Shipyard, Vallejo, CA.

APPROACH: Abrasive blasting of steel surface produces large amounts of spent abrasive at Navy shipyards that are often classified as hazardous waste. Disposal sites are increasing the cost of land disposal for used abrasive. Changes in procurement specifications have reduced the hazardous components of virgin abrasives; however, the spent abrasives are contaminated by coatings blasted from tanks, hulls, and other ship surfaces. These coatings add copper and other potentially toxic materials to the spent abrasives, resulting in them being classified as hazardous waste under California law. U.S. EPA Land Ban Disposal restrictions will eliminate the land disposal of untreated spent abrasives in California. The recent addition of 25 pesticides to the RCRA Sub-Part D Waste List raise the probability that copper, the current biocide use in hull antifouling paints, will be added to the EPA list in the future. Copper is already included in the California restrictions. If copper is added to the EPA list, this would invoke Land-Ban Disposal restrictions for spent abrasives produced at all Navy shipyards.

This technology demonstration will result in the completion of a 3-ton per hour spent abrasive detoxification/recycling facility at Mare Island Naval Shipyard in Vallejo, California. The facility could potentially be used to process additional spent abrasives from Long Beach, and Puget Sound Naval Shipyards.

This technology demonstration will be successful because it is an adaptation of proven sloped-grid, fluidized bed calciner technology developed by the Institute of GS Technology (IGT). A pilot plant test performed in FY89 using spent abrasive from U.S. Navy shipyards (DTRC report SME-CR-03-89) successfully demonstrated a recycle recovery rate of 70% from once-used grit. This recovery rate should provide a recycled abrasive reusability rate of between 2 and 3.5 times, depending on blasting media friability. The recycled product not only met the requirements of MIL-A-22262A (SH) but was proven adequate for reuse by actual blasting tests on a ship's hull.

The recycling facility will be designed and constructed within an 18-month period, including required building permits and the filing of an environmental assessment. It will be designed to process various abrasives, including coal slag, copper slag, aluminum oxide, and garnet. Demonstration tests will validate performance and efficiency. The grit-fines produced from the process that are unsuitable for reuse as abrasive will be evaluated for use in the manufacture of concrete, masonry bricks, and other durable products, eliminating the need for their disposal. Known potential uses include using the grit-fines as a feedstock in cement production or as an additive in brick manufacture. Once testing is complete, continued operation of the facility will become the responsibility of Mare Island Naval Shipyard to operate themselves as a Government-owned, Company operated facility.

BENEFITS: Spent sandblasting abrasives are considered a hazardous waste in California and therefore must be disposed of in hazardous waste landfills. Mare Island currently pays $73.00 per ton for a new abrasive and $660.00 per ton for disposal. An economic analysis done in a FY91 NAVFAC Facility study (NAVFAC project number P-316) calculated that if Mare Island recycled its spent abrasive in this facility, an economic payback of 2.1 years could be achieved, with an internal rate of return of 85% and a present-value savings of $6.7M. This analysis is based on processing 2,200 tons of abrasive per year at less than 20% of plant capacity. If spent abrasives from other Navy West Coast Shipyards (Long Beach and Puget Sound) or from commercial or other government facilities are processed, these savings could be significantly higher. Additionally, if the plant is used to full capacity, the cost of the recycled grit will approach $50 per ton, making it competitive with the cost of new grit for potential resale. The demonstrated technology can be transferred to other government agencies and industries which produce spent abrasive. Army and Air Force have expressed interest.

MILESTONES:

Develop facility design and construction contract. Perform the environmental assessment. Apply for building permits. Design the sloped-grid fluidized bed system.	FY 92
Construct the sloped-grid, fluidized bed system and evaluate it for performance and efficiency.	FY 93
Investigate potential uses for grit-fines and assess local markets for their use.	
Transition operation and maintenance of facility to Mare Island Naval Shipyard.	FY 94

FUNDING ($K):

FY92	FY93	FY94
560	1,590	50

RESEARCH ACTIVITY: Navy, David Taylor Research Center, Code 2834, Annapolis, MD 21402-5000, (301) 267-3831

RESEARCH TITLE: Treatment of Waste Sodium Nitrite Solutions

OBJECTIVE: Develop a process to convert hazardous sodium nitrite waste water solutions generated in the process of ship overhaul to environmentally benign compounds that can be disposed of at a low cost.

APPROACH: Develop a process and equipment to oxidize sodium nitrite to innocuous nitrogen gas. It is possible that the sodium nitrite solution may contain heavy metals. Electrochemical techniques or bioaccumulation can be used to remove metals. Alternatively, an industrial waste treatment plant may be able to treat the metal laden solution to remove heavy metals by precipitation.

BENEFITS: Sodium nitrite is a corrosion inhibitor often added to boiler feedwater, boiler lap water, and hydroblast feedwater. Sodium nitrite is toxic to aquatic life forms. Also, heavy metals may enter the solution from corrosion or boiler cleaning operations. The Navy pays about $600,000 each year to dispose of about 1.4 million gallons of this hazardous waste water. A process which converts hazardous sodium nitrite waste waters to an environmentally benign form could save the Navy a minimum of half of million dollars per year in avoided disposal costs.

PARTNERS AND RELATED ACTIVITIES: None identified at this time.

MILESTONES:

Design and build prototype $NaNO_2$ treatment unit	FY92
Field test treatment unit	FY92
Transition to Fleet use	FY93

FUNDING ($K):

FY92	FY93
120	100

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA

RESEARCH TITLE: Ship Surface Preparation and Paint Removal Technologies

OBJECTIVE: Develop non-polluting paint removal and surface preparation technologies and equipment for shipboard surfaces.

APPROACH: Navy shipyards generate thousands of tons of waste every year cleaning, depainting, and preparing shipboard surfaces like hulls, freeboards, tanks, nonskid surfaces, machinery, electrical components, and radar assemblies. Much of this waste must be classified and disposed as hazardous waste (HW). The cost and difficulty of disposing of these wastes have increased significantly in the past ten years due to increasingly restrictive regulations. Coatings are normally removed from large surface areas like ship hulls and tanks by abrasive blasting. Abrasive blasting generates spent grit which must be disposed of as HW in California and creates fugitive dust which will exceed new Clean Air Act standards. Many shipboard surfaces ar cleaned of grease, oil, and paint with solvents. Use of solvents releases VOCs and CFCs into the atmosphere and generates hazardous waste. Other shipboard surface areas such as bilge spaces are cleaned and prepared for repainting with caustic solutions, which are also hazardous and must be disposed of accordingly.

Abrasive blasting, solvent cleaning, and caustic cleaning are all widely accepted by Navy shipyards because they are processes that can be used for many applications. Abrasive blasting, for example, can be used to remove paint from almost any large steel surface. Alternative technologies exist which would generate less waste than these processes and would be more cost effective to use for specific applications. Several alternative technologies have been identified for potential shipyard use including: sodium bicarbonate blasting, high pressure water blasting with abrasive injection, solid CO_2 blasting, and laser depainting.

Each alternative technology will be developed in four phases. In Phase I, a feasibility study of the alternative technology will be performed to identify those shipyard applications for which the technology is most suitable. In Phase II, the technology will be tested using existing equipment to measure its usefulness in the potential applications identified in Phase I. In Phase III, if required, engineering and design modifications to the existing equipment will be developed and implemented to make existing equipment more responsive to shipyard needs. In Phase IV, equipment developed in Phase III will be demonstrated on a production level in a shipyard and a first article unit will be procured. At this point in time, the technology will be ready for use by Navy shipyards. This approach can be modified to fit the maturity of the technology. Phases I and II have already been completed for CO_2 blasting and automated high pressure water blasting with garnet injection. Phase I has been completed for sodium bicarbonate blasting.

__BENEFITS__: Implementation of alternative technologies for surface preparation and for paint removal would result in significant cost saving for Navy shipyards. By eliminating or reducing the generation of wastes, these technologies will significantly reduce HW handling and disposal costs while limiting liability.

Reducing the use of abrasive grit will allow shipyards to comply with land-ban and dust emission regulations. In many cases, the new technologies will be more efficient than existing methods of paint removal and surface preparation, and will reduce production costs. Cleanup costs and requirements will be reduced.

The new technologies will result in less environmental insult, and will often create a safer environment for the workers. Reducing the use of solvents will result in lower VOC and CFC emissions. These technologies will benefit not only the Navy but also other industrial activities requiring paint removal or surface cleaning.

__PARTNERS AND RELATED ACTIVITIES__: DTRC, in coordination with Norfolk Naval Shipyard and Mare Island Naval Shipyard, evaluated high pressure water blasting equipment with abrasive injection, DTRC report entitled, "Ship Hull Paint Removal Comparison Study," March 1989. This report indicated that high pressure water blasting with garnet injection is capable of removing ship hull paint, provided the existing stationary nozzles could be made to rotate. DTRC and Norfolk Naval Shipyard then developed a rotary abrasive slurry nozzle using this technology. DTRC evaluated solid carbon dioxide paint removal equipment at Alpheus Cleaning Industries Inc and reported the results in DRTC report TM-28-88-45, "Evaluation for CO_2 Blasting for Coatings Removal" October 1988. Norfolk Naval Shipyard performed a follow up evaluation in 1989. We also performed a comparative study between the two commercially available CO_2 blasting systems made by Alpheus Cleaning Industries, Inc. and Cold Jet Incorporated in 1991. Results of these studies indicate that solid carbon dioxide blasting is useful for degreasing operations and for the removal of antifouling and other soft paints. Work on laser depainting is currently being performed at several Federal and private facilities around the country, including Oak Ridge National Laboratory. DTRC is performing a study to identify technology gaps which, if filled, would allow the application of technology, resulting in reduced HW disposal costs at Navy shipyards.

__MILESTONES__:

FY92: Building and demonstrate prototype aumtomated high pressure water blasting using Navy developed rotary slurry nozzle (Phases III and IV). Test Sodium bicarbonate blasting for bilge cleaning (Phase II). Continue to identify new technologies and determine the feasibility of applying those technologies to shipboard paint removal and surface preparation operations (Phase I).

FY93: Perform a feasibility study on the application of laser depainting technology for shipboard use (Phase I). Prepare procurement package for first article high pressure water blasting head with garnet injection (Phase IV).

FY93: Procure first article high pressure water blasting head with garnet injection and demonstrate in shipyard (Phase IV). Test laser depainting technology on test samples of shipboard coatings (Phase II).

FY94: Continue development of laser depainting technology (Phase III).

FUNDING ($K):

FY92	FY93	FY94	FY95
250	600	500	200

RESEARCH ACTIVITY: David Taylor Research Center, Code 2834, Annapolis, MD 21402-5000. Technical Point of Contact is Mr. Carl Adema 301-267-3831.

RESEARCH TITLE: Organic Protective Coatings and Application Technology

OBJECTIVE: To develop high performance, non-toxic, low volatile organic compounds (VOC) content coatings for Navy use. Organic coatings are the primary source of protection against environmental degradation for Navy aircraft (A/C), weapon systems and ground support equipment (GSE). In addition, these materials are used to provide passive countermeasures against many enemy threats. There are a large number of different coating systems currently used by the Navy due to the diverse nature of their functions, the variety of substrates and alloys to which they are applied, and the severe nature of their operational environment. These protective coatings contain toxic inhibitors (i.e. lead, chromates, etc.) and high VOC contents. These components are released during painting operations as organic and toxic air emissions. Federal, state and local environmental agencies like the EPA and California Air Quality Management Districts (AQMD) classify these materials as hazardous and restrict their emissions through regulations like the Clean Air Act, Clean Water Act, CERCLA, Resource Conservation and Recovery Act (RCRA), as well as local EPA and AQMD rules. In addition, OPNAVINST and CNO directives require significant reductions in hazardous waste generated by the Navy. Finally, painting operations at maintenance depots are a major contributor to hazardous material and waste generation in the DOD. Therefore, it is necessary to develop new high performance coatings that will meet current and future environmental restrictions while allowing the Navy to continue painting operations.

APPROACH: A full spectrum approach for reducing the VOC and air toxic emissions from protective coatings will be pursued. To being with, research in low VOC polymer technology will be used to produce low VOC binder systems. Reactive monomers/oligomers and diluents will be develop to obtain low viscosity, low VOC binder systems for future organic coatings. In addition, recent developments in waterborne resin technology by coatings manufacturers will allow for the development of high performance water-borne topcoats which are compliant with these regulations. Coating corrosion resistance, physical performance properties, and VOC content will be evaluated to develop the best materials.

Several recently developed VOC compliant, non-toxic alternative materials will be investigated for this program. These compliant coating systems include Unicoat (a non-lead, non-chromate, low VOC self-priming topcoat); compliant lacquer topcoats, and non-toxic inhibitor systems. The non-toxic inhibitor systems will be used to develop replacements for the current lead and chromate containing materials. These materials will be optimized, service evaluated, and implemented for Navy use. Finally, conventional air spray used to apply these materials has a transfer efficiency of only about 28%. Therefore, investigating high transfer efficient spray application equipment would significantly reduce the amount of air emissions from painting operations. Application equipment such as air-assisted airless, electrostatic, high volume low pressure (HVLP), and plural component will be evaluated. The optimum coatings developed through this program will be service tested at NADEPs and transitioned to fleet use through specification development or modification and design changes.

BENEFITS: The development of non-toxic, VOC compliant coatings will enable the Navy to meet current and future environmental regulations as well as reduce the total amount of hazardous waste the Navy generates. In addition, these new materials will eliminate the need for the installation of extremely expensive control equipment (i.e. $1-5M per spray booth for VOC emission control). This effort is in direct support of Navy and DOD hazardous waste minimization policies/directives. In addition to reduced handling and disposal costs, Navy A/C and equipment operational readiness will be maintained by using these new coatings. This is particularly important considering the cost of these A/C, weapon systems, and GSE as well as the severely deleterious environment in which the Navy operates. This technology could also be transitioned to many areas of the commercial sector (aerospace, automotive, marine, etc).

PARTNERS AND RELATED ACTIVITIES: These developmental efforts will be coordinated with the resin/coatings industry, Air Force, Army, and aerospace industry.

MILESTONES:

Service demonstration of Unicoat - self-priming topcoat	FY92
Optimize/service demonstration of compliant lacquer topcoats	FY92
Develop water-borne high performance topcoats	FY92
Develop low VOC polymers (reactive diluents, monomers, etc.)	FY92
Investigate high transfer efficiency application equipment	FY92
Develop non-toxic inhibited organic coatings	FY92
Implement Unicoat - self-priming topcoat	FY93
Implement compliant lacquer topcoats	FY93
Optimize base water-borne topcoat for A/C and GSE	FY93
Develop A/C coatings based on low VOC polymers	FY93
Implement high transfer efficiency application equipment	FY93
Service demo of non-toxic inhibited organic coatings	FY93
Optimize low VOC polymer coatings for A/C and GSE	FY94
Service demonstration of optimum water-borne coatings	FY94
Implement non-toxic inhibited organic coatings	FY94
Service demo of optimized low VOC polymer coatings	FY95
Implement water-borne topcoats	FY95
Implement optimized low VOC polymer coatings	FY96

FUNDING ($K):

FY92	FY93	FY94	FY95	FY96
500	500	600	700	800

RESEARCH ACTIVITY: Navy; Naval Air Systems Command; Washington, DC 20361; A/V 222-2447

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93

RESEARCH TITLE: Non-Chlorinated Strippers and Low VOC Solvents

OBJECTIVE: To identify replacements for methylene chloride based chemical paint strippers and to identify low VOC (volatile organic compound) content solvents for use on Navy aircraft, weapon platforms and ground support equipment (GSE). Current chemical paint strippers contain hazardous components like phenols, methylene chloride and chromates and paint removal operations at maintenance depots has been determined to be a major contributor to hazardous waste generation in DOD. Recently, OSHA has reduced the permissible exposure limit for methylene chloride from 400 ppm to 50 ppm, forcing users to make extensive changes in ventilation and personal protection. In addition, volatile organic solvents such as methyl ethyl ketone (MEK) are used for solvent wipedown of aircraft prior to painting and post-painting cleanup. Other procedures require the use of stoddard solvent for cleaning aircraft parts in solvent tanks. Regulations like the Clean Air and Water Acts, CERCLA, RCRA, and local EPA and AQMD rules limit or prohibit the use and disposal of these hazardous materials. In addition, OPNAVINST and CNO directives require a 50% reduction in hazardous waste by 1992. There is an urgent need to evaluate alternative chemistries for paint removers for use at Naval Aviation Depots in order to identify a product or a chemistry capable of satisfying existing and fire regulations while maintaining aircraft performance and operation readiness. In addition, low VOC non-toxic alternative to solvent cleaners need to be developed.

APPROACH: Non-methylene chloride alternatives must exhibit workable performance characteristics while reducing the impact of stripper waste on disposal operations. Because there are so many different substrates/alloys and coating systems currently used by the Navy, non-hazardous paint removers will also have to be versatile. This program will identify the best alternatives for ambient coating removal operations. Procedure efficiency, effects on substrate surface, hazardous waste generation, and applicability will be investigated in order to determine the best procedure for Navy applications. The best alternative material will be demonstrated at a NADEP and transitioned to fleet use through specification modification and design changes.

Solvent cleaners must be effective on a diverse combination of soils from baked on carbon to aircraft greases and lubricants. This program will develop solvent blend formulations which will be evaluated with laboratory performance and cleaning efficiency tests. The best blends will be further evaluated for vapor pressure, odor evaporation rate, safety, and cost. The optimum material will be service tested at a NADEP and transitioned to fleet use through specification modification and design changes.

BENEFITS: The elimination of the methylene-chloride-based chemical paint strippers would significantly reduce the total amount of hazardous materials generated by Navy maintenance facilities. In addition, the development of low VOC solvents would significantly reduce the total amount of hazardous materials emissions generated. This effort is in direct support of Navy and DOD hazardous waste minimization policies/directives. In addition to reduced handling and waste disposal costs, Navy aircraft and equipment must be properly maintained. This is particularly important considering the cost of aircraft weapon systems and GSE as well as the severely deleterious environment in which the Navy operates. This technology could also be

transition to many areas of the commercial sector (aerospace, automotive, marine, etc).

PARTNERS AND RELATED ACTIVITIES: Development of non-methylene chloride paint strippers will be performed by the Air Force (Tyndall AFB) and aerospace industry. Development of low VOC solvents will be coordinated with the Air Force, DOE, and aerospace industry.

MILESTONES:

Evaluate alternative stripper chemistries	FY92
Optimize process parameters	FY93
Service demonstration of optimized alternative	FY94-FY95
Develop low vapor pressure alternative solvents	FY92
Optimize solvents/process	FY93
Service demonstration of optimized materials	FY94-FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
300	600	900	500	2,300

RESEARCH ACTIVITY: Navy; Naval Air Systems Command; Washington, DC 20361; A/V 222-2447

RESEARCH TITLE: Aircraft Depainting Technology

OBJECTIVE: To develop a replacement for chemical paint stripping use on Navy aircraft, weapon platforms, and ground support equipment (GSE). Current chemical paint strippers contain hazardous component like phenols, methylene chloride, and chromates. Paint removal operations at maintenance depots have been determined to be a major contributor to hazardous waste generation in the DOD. Federal agencies like the EPA and state agencies like the California Air Quality Management Districts (AQMD) have begun to restrict the use of these hazardous materials. Regulations like the Clean Air and Water Acts, CERCLA, RCRA, and local EPA and AQMD rules limit or prohibit the use and disposal of these hazardous materials. In addition, OPNAVINST and CNO directives require significant reductions in hazardous waste generated by the Navy. Several generic alternative stripping methods to the present chemical removers are being developed. These techniques, however, need to be optimized and evaluated for use at Naval Aviation Depots. Therefore, to comply with existing and future regulations while maintaining aircraft performance and operational readiness, these alternative methods need to be investigated.

APPROACH: Alternative methods of coating removal that meet increasing waste disposal constraints must be developed to maintain aircraft rework operations while reducing hazardous waste generation. Because there are so many different substrates/alloys and coating systems currently used by the Navy, these nonhazardous paint removal processes will also have to be versatile. This program will identify the best alternatives from existing and developmental methods such as non-hazardous chemical paint strippers (i.e. materials that do not contain chromates, methylene chloride, phenol, etc.); enzymatic strippers; and mechanical removal procedures (PMB, flash lamp, UV, dry ice stripping, etc.). Procedure efficiency, effects on substrate surface, hazardous waste generation, and applicability will be investigated in order to determine the best procedure for Navy applications. Comparison of techniques as well as advantages/disadvantages will also be performed. Mechanical removal procedures eliminate the use of hazardous chemicals; however, several individual mechanical techniques damage the substrate surface during the removal process. Since some sections of aircraft skins are very thin, this is not acceptable. However, if several techniques are combined to remove the coating, the surface damage could be eliminated/minimized to an acceptable level. For example, one possible combination is flash lamp/dry ice stripping. The flash lamp would degrade the coating system and the dry ice stripping perform the final removal at a reduced pressure (i.e. reduced surface damage). Finally, the treatment of the blast media used in these mechanical techniques will be investigated for waste reduction. The best alternative material will be demonstrated at a NADEP and transitioned to fleet use through specification modification and design changes.

BENEFITS: The elimination of the majority of chemical paint strippers would significantly reduce the total amount of hazardous materials generated by the Navy. This effort is in direct support of Navy and DOD hazardous waste minimization policies/directives. In addition to reduced handling and waste disposal costs, these methods of coating removal will contribute to the proper maintenance of Navy aircraft and equipment. This is particularly important considering the cost of these A/C, weapon systems, and GSE as well as the severely deleterious environment in which the Navy operates. This technology could also be transitioned to many areas of the commercial sector (aerospace, automotive, marine, etc.).

PARTNERS AND RELATED ACTIVITIES: Development of an alternative stripping process will be coordinated with efforts being performed by the Air Force (Tinker AFB, Kelly AFB and Tyndall AFB) and aerospace industry (MCAIR, Boeing, etc.). The University of Maryland (bioreactor scale-up facility) will collaborate with the enzymatic stripping effort.

MILESTONES:

Evaluate/optimize alternative processes' parameters	FY92
Investigate flash lamp/dry ice combination (joint Navy/Air Force program)	FY92
Investigate blast media treatment	FY92
Characterize enzyme system activity/stability	FY92
Service demonstration of optimized alternative	FY93
Service demonstration of flash lamp/dry ice combination	FY93
Select genes for enzyme synthesis (recombinate DNA method)	FY93
Implementation of optimized alternative	FY94
Production of a batch of enzymes for stripper studies	FY94
Conduct enzyme stripping studies	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
500	900	800	900	3,100

RESEARCH ACTIVITY: Navy; Naval Air Systems Command; Washington, DC 20361; A/V 222-2447

RESEARCH TITLE: Electroplating Waste Reduction

OBJECTIVE: Develop, test and evaluate techniques for reducing hazardous waste and wastewaters from Navy electroplating and metal finishing operations.

APPROACH: Hazardous waste disposal of spent electroplating and metal finishing process baths will be reduced using purification techniques that prolong the useful life of these baths. Electrodialysis and coupled transport technology will be evaluated for removal of bath impurities. Wastewater discharges and hazardous sludges generated from convention wastewater treatment will be reduced using electrolytic recovery techniques. Electrolytic recovery will be field-tested and evaluated for point source recovery of silver, copper, nickel, tin-lead, zinc, and gold from electroplating rinsewaters. (Note: Completed efforts on cadmium cyanide containing wastewaters has shown a 99% reduction with point source electrolytic recovery). Final rinsewaters generated from cadmium cyanide electroplating will be treated using an innovative ion exchanged (IX) recover process. Developmental testing and evaluation of the IX process will be conducted at NADEP North Island using the pilot plant system designed in previous efforts. Operational test and evaluation of a prototype IX system will be conducted following successful developmental testing. Design, operation, and maintenance requirements will be developed for technology transfer of each electroplating waste reduction technique.

BENEFITS: Navy plating shops are burdened by the cost of treatment and disposal of electroplating/metal finishing operations. Development of bath purification systems will reduce hazardous waste generation by 400,000 gal/yr with a fourfold increase in process bath life. Disposal costs will be reduced by $1M/yr. Electrolytic recovery systems will reduce treatment and disposal costs by $750K/yr and valuable metals will be recovered. Electrolytic recovery systems will reduce discharges of metal contaminants by up to 99%, providing increased compliance with regulations. The ion exchange recovery system will eliminate cadmium cyanide discharges and recovery cadmium and sodium cyanide for reuse without generation of hazardous sludges.

PARTNERS AND RELATED ACTIVITIES: Development of minimization technologies for metal cleaning and electroplating wastes will continue to be a cooperative effort among all DoD laboratories. Field testing of technologies will be in participation with site personnel from selected NSYs, NADEPs, or other Naval Shore facilities.

MILESTONES:

Conduct field testing of electrodialytic bath purification system.
Complete field testing of electrolytic recovery systems for each metal.
Conduct development testing of IX process. FY92

Complete operational testing of electrodialytic system for each applicable process bath and develop operation and maintenance requirements. Conduct laboratory testing of coupled transport technology. Develop technology transfer documentation for electrolytic recovery systems. Design and construct prototype IX system and initiate field testing. FY93

Develop technology transfer documentation for electrodialytic systems. Conduct field testing of coupled transport system. Complete operational testing for IX system and develop technology transfer documentation. FY94

Develop design, operation, and maintenance requirements for coupled transport systems and prepare technology transfer documentation. FY95

FUNDING ($K):

	FY92	FY93	FY94	FY95
Bath Purification Electrolytic Recovery Ion Exchange (IX)	340	575	300	150

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, (805) 982-1353 AV 551-1353

RESEARCH TITLE: A/C Maintenance Chrome Replacement

OBJECTIVE: To replace chromates (Cr) currently used in aerospace materials and processes on Navy aircraft, weapon platforms, and ground support equipment. Chromium VI is a carcinogen and Federal agencies like the EPA and state agencies like the California Air Quality Management Districts (AQMD) have begun to restrict the use of this hazardous material. Regulations like the Clean Air and Water Acts, CERCLA, RCRA and local EPA and AQMD rules limit or prohibit the use of chromate containing materials. In addition, OPNAVINST and CNO directives require significant reductions in the amount of hazardous waste generator by the Navy. Chromate-containing materials used in production and depot level maintenance operations have been determined to be a large contributor to this overall waste generation. Therefore, in order to comply with these regulations while maintained aircraft performance and operational readiness, chrome-free alternative have to be developed.

APPROACH: Non-chromate alternative materials and processes will be investigated for current anodizing, pretreating, sealing, adhesive, and corrosion-preventive processes. The approach taken for the development, test and evaluation, demonstration, and implementation. Chromic acid anodizing (CA), a common inorganic coating for pretreating aluminum prior to painting, will be used as an example of this approach. This program will identify the best alternatives to CA from existing and developmental coating methods. These alternatives include thin sulfuric, phosphoric acid anodizing, and Boeing Aerospace Corp's Boric-Sulfuric Acid Anodize. Selected alloys will be processed and tested to determine which replacement systems will provide equivalent corrosion resistance and paint adhesion while maintaining the existing mechanical properties provided by chromic acid anodizing. The most promising alternatives will be optimized for aircraft applications. The best alternative material will be demonstrated at a NADEP and transitioned to fleet use through specification modification and design changes. This approach will be taken for the development of non-chromate pretreating materials (alkaline cleaners and deoxidizers, etc.), adhesives, sealants, and other aerospace chromate containing materials.

BENEFITS: The elimination of chromic acid anodizing, chromated alkaline cleaners and deoxidizers, and sealants and adhesives, significantly reduces the total amount of chromium emitted from Navy operations. Elimination of chromic acid anodizing also eliminates the need for expensive emission control equipment (estimated at several $M per facility) required by CA and AQMD legislation. Non-funded programs have already been implemented at NADEPs to meet these new regulations. Furthermore, these alternatives also significantly reduce rising disposal costs of chromium from Navy operations. This effort is in direct support of Navy and DOD hazardous waste minimization policies/directives. In addition, without the use of adequate replacements, aircraft operational readiness could be curtailed by excessive environmental degradation. This is particularly important considering the cost of Navy A/C, weapon systems, and GSE as well as the severely deleterious environment in which the Navy operates. This technology could also be transitioned to many areas of the commercial sector (airlines, automotive, equipment manufactors, etc).

PARTNERS AND RELATED ACTIVITIES: Evaluation/demonstration of chromium-free alternatives will be coordinated with the Air Force Civil Engineering Services Center (Tyndall AF), Army Materials Technology Laboratory (Watertown, MA) and aerospace industries (Boeing, Rohr, Grumann, MCAIR, etc.).

MILESTONES:

Transition/implement non-Cr cleaners and deoxidizers	FY92
Evaluate/optimize non-Cr acid anodize processes	FY92
Initiate non-Cr adhesives and sealants development	FY92
Service demonstration of non-Cr anodize	FY93
Evaluate/optimize non-Cr adhesives and sealants	FY93
Implementation of non-Cr anodize	FY94
Service demonstration of non-Cr adhesives and sealants	FY94
Transition/implementation of non-Cr adhesives and sealants	FY95

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
200	400	600	800	2,000

RESEARCH ACTIVITY: Navy; Naval Air Systems Command; Washington, DC 20361; A/V 222-2447

RESEARCH TITLE: IVD Aluminum

OBJECTIVE: To fully utilize IVD technology for aircraft systems as a replacement for cadmium. Though this technology is not new, engineering work is required for full implementation and approval.

APPROACH: Conversion from cadmium to IVD aluminum will greatly reduce the hazardous waste generated by the NADEPs. Material Engineering Support is required to develop appropriate IVD parameters on a component-by-component basis. Work involves substantial laboratory testing and process monitoring to assure coating integrity and conformance to applicable specifications. Corrosion prevention on Naval aircraft is of prime importance to system integrity; Naval aircraft being in a continuous salt water atmosphere presents requirements not normally associated with land base weapons systems. The full implementation of IVD will enhance other marine applications in the civilian sector.

BENEFITS: A primary benefit of this substitution would be the elimination of cyanide cadmium plating. Conversion from cadmium to IVD aluminum will greatly reduce the hazardous waste generated by the NADEPs. Cost saving of $274,000 have been projected for the effect of substitution of IVD aluminum for cadmium plating for bomb rack components reworked at NADEP JAX. The indicated savings are for process savings ($124,000) and for cost savings from disposal of hazardous waste resulting from processing of all reworked bombrack components ($150,000). Cost savings from across the board substitution of IVD aluminum for cadmium plating should be at least an order of magnitude greater than figures indicated above at NADEP JAX alone.

PARTNERS AND RELATED ACTIVITIES: Ion vapor deposition (IVD) capability has been established at many depots. Equipment is in place and artisan training is underway. NADEP JAX has queried other NADEPs on plans for substitution of IVD aluminum for cadmium plating.

MILESTONES:

Demonstrate Feasibility of IVD Aluminum at NADEP Pensicola.	FY 92
Prepare Technical Manual on Changes to Allowable IVD Use.	FY 94

FUNDING ($K):

FY92	FY93	FY94	TOTAL
50	50	50	150

RESEARCH ACTIVITY: NADEP Pensacola, FL AV 922-3553

RESEARCH TITLE: Aluminum-Manganese Electroplating from a Molten Salt Bath

OBJECTIVE: To replace 100% of the cadmium plating currently used on Naval aircraft, weapons platforms and ground support equipment. Cadmium is a heavy metal pollutant and a carcinogen. It is anticipated that cadmium will be restricted by the EPA and various state Departments of Environmental Resources. OPNAVINST and CNO directives require 50% reduction in hazardous waste by 1992. Presently, cadmium plating is used in production and depot level maintenance operations. Therefore, in order to comply with these regulations while maintaining aircraft performance and operational readiness, a cadmium-free plating alternative has to be developed and validated.

APPROACH: Cadmium plating is a common inorganic corrosion preventive coating which also offers lubricity when not over coated with an organic coating system. Cadmium plating is frequently used for fasteners and other very high tolerance parts because of the dual qualities of lubricity at minimal thickness and superior sacrificial corrosion protection. A replacement material for cadmium will require similar mechanical and performance properties over the full spectrum of applications for which cadmium is presently used. A molten salt bath process (versus the traditional aqueous electrolytic plating bath) will be identified and evaluated to determine if the process using aluminum-manganese fulfills all plating requirements. The best aluminum-manganese concentrations for Naval aircraft use will be isolated through a test program which examines al-mn systems on test coupons of various materials and sizes. This bath formulation will then be established as a full-size prototype at a selected NADEP. Following full scale tests, al-mn will be transitioned to the fleet through specification modification and design changes.

BENEFITS: It has been known for decades that aluminum-manganese deposited from a molten salt bath could produce coatings very similar to cadmium with respect to dimensional tolerances, corrosion protection, stress relief parameters and cycles, blind hold plating, and lubricity while providing the benefit of no heavy metal pollution. No other inorganic coating system suggested for cadmium replacement will fulfill all of these requirements. In addition, cycle fatigue compared to bright cyanide cadmium electroplating will substantially reduce the total amount of cadmium emitted from Naval operations. This effort is in direct support of Navy and DOD hazardous waste minimization policies/directives. Without the use of an adequate replacement, aircraft operational readiness could be curtailed by excessive environmental degradation. This is particularly important considering the cost of Navy A/C, weapon systems, and GSE as well as the severely deleterious environment in which the Navy operates. This technology could also be transitioned to many areas of the commercial sector (airlines, automotive, equipment manufacturers, fastener manufacturers, etc.).

PARTNERS AND RELATED ACTIVITIES: Evaluation/Demonstration of an aluminum-manganese molten salt bath inert environment plating facility will be coordinated with the Air Force (Tyndall AFB) and several potential aerospace industries.

MILESTONES:

Design Start	FY92
Design Completion	FY93
Prototype Construction and Test Program	FY94
Test Program Completion and Demonstration on Moderate Size Fleet Parts	FY95
Specification Modification, Manual Revisions, and Demonstration on Full Scale Fleet Parts	FY96

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
100	200	200	350	850

RESEARCH ACTIVITY: Navy; Naval Air Systems Command; Washington, DC 20361; A/V 222-2447

RESEARCH TITLE: HALON Replacement

OBJECTIVE: To evaluate applicability of replacements for HALON 1211 and 1301 in naval aviation-unique applications and assure that the alternatives developed will perform satisfactorily in naval aviation systems.

APPROACH: Joint programs for HALON alternatives research are currently underway with the services and industry. A considerable amount of developmental work remains to be done in this area. Due to the various applications for HALON and the limited number of candidate replacements, some system redesign or overhaul is anticipated. Planning for such system modification requires additional time both for engineering and scheduling of hardware to be modified or replaced. Monitoring of the alternative programs is necessary to assure all redesign/overhaul requirements are identified. Also, further test of alternatives in Navy-unique equipment may be necessary before across-the-board alternatives approval is issued.

BENEFITS: Success in this effort will assure that the international agreement on the banning of ozone depleting substances will be met on schedule. Without support in this area, the Navy will be behind schedule in replacing both HALON 1211 and 1301.

PARTNERS AND RELATED ACTIVITIES: This developmental area, along with the testing and evaluation necessary for proper replacement, is a well coordinated effort with both the Air Force and the Naval Sea Systems Command. It is important to do much of the work in-house due to the need to prevent fostering a sole-source procurement situation once replacements have been developed. Industry efforts have been helpful but will only lead to a long-term single source situation. The combined DOD effort and expertise is considerably more advanced in approach.

MILESTONES: The major milestone is to transition the technology from pollution prevention to technology transfer within two years. This is based on the success of the joint HALON replacement effort and initial developmental work based on Navy-unique equipment.

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
120	200	200	200	720

RESEARCH ACTIVITY: Naval Air Development Center; Warminster, PA, AV 441-2704

RESEARCH TITLE: Reduced Solids Precipitation Technology Application

OBJECTIVE: Adapt the USAF ferrous sulfate sludge precipitation to Navy industrial waste treatment plants (IWTPs). Every IWTP is custom designed to treat a specific combination of waste streams, so the ferrous sulfate process cannot be recommended for use at Navy IWTPs without first demonstrating that it works on the combination of plating, stripping, and cleaning wastes generated by Navy industrial processes.

APPROACH: Improved methods of heavy metal precipitation using ferrous sulfate instead of lime will result in significant reductions in sludge generation. The USAF ferrous sulfate process produces only 8% to 10% of the volume of sludge of the lime precipitation process and produces a higher quality liquid effluent. This process has been installed at Tyndall AFB with a resulting cost reduction at 70%, a reduction in sludge generation of 10% of previous levels, and a lower heavy metal effluent level.

BENEFITS: Twelve Navy IWTPs generated 7,200 tons of hazardous sludge in 1985 using lime precipitation at a cost of $1.8 million per year. Sludge reduction by better dewatering and reduced influents can reduce the amount of sludge generated by 50%. Improved methods of heavy metal precipitation can significantly further reduce the amount of sludge generated and reduce the amount of sludge generated and reduce costs of disposal.

PARTNERS AND RELATED ACTIVITES: The subject waste treatment process was developed by the Air Force. USAF guidance will be sought for Navy pilot plant design, installation, and test.

MILESTONES:

Construct and test pilot plant at a NSY or NADEP. FY93

FUNDING ($K):

FY92	FY93
100	50

RESEARCH ACTIVITY: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043

RESEARCH TITLE: In Situ Contaminant Mobility Reduction Using Surfactant

OBJECTIVE: The use of cationic surfactant for remediation of sites with groundwater contamination will be examined. Cationic surfactants can strongly bind to aquifer materials to act as a stationary sorbent for organic contaminants. The mobility of the contaminants could be significantly reduced which would allow more time for degradation reactions to occur.

- General Problem Statement. Discharges of jet fuel and solvents to subsurface environments have led to contamination of groundwater resources. Cost-effective remedial action technologies must be explored.

- Limitation/Restrictions of Current Technology. The current common practice is to pump the contaminated groundwater and treat it aboveground. This has proven to be expensive due to capital costs, maintenance, and the long time required for aquifer cleanup. In situ biodegradation is an emerging technology which holds promise. Engineering a suitable environment to enhance biodegradation in the subsurface, however, has proven difficult. Soil venting is a remedial option that is gaining wide acceptance for a contamination source in unsaturated soils. However, some contaminants sink below the water table and are not accessible by this method. Also, soil venting will not remove compounds with low vapor pressures.

BENEFITS: A more cost-effective remedial alternative would be available for many Air Force groundwater contamination sites.

REQUIREMENTS: This project supports SAC SON 04-82. The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The problem of fuel and solvent contaminated groundwater has been well documented in IRP site investigation reports.

- User/Sponsor. The RIP, MAJCOMs, and civilian environmental engineering community will use this technology.

- Advocates/Supporters. HQ USAF/CEV, AFCEE, and MAJCOMs are the advocates.

- Comments. This research is being coordinated with in-house research efforts.

TECHNICAL APPROACH:

- Major Tasks of Effort. Evaluate potential cationic surfactants for their ability to sorb onto aquifer materials and to act as a sorbent for common groundwater contaminants. Evaluate the compatibility of microorganisms with surfactant-modified aquifer material. Evaluate the ability of microorganisms to degrade contaminants in the presence of surfactant modified aquifer materials.

- Methodology/Approach Used to Perform Tasks. Aquifer materials will be collected for the studies. Laboratory experiments will be performed using the

aquifer materials, selected cationic surfactants, selected contaminants, and soil microorganisms to accomplish the above tasks.

- Deliverable Requirement. The principal deliverable is a detailed evaluation of the use of cationic surfactants as a remedial action technology. All experimental designs, results, and data interpretations will be documented in the final report.

TECHNOLOGY ASSESSMENT: Milestones/Experiments Used to Demonstrate Success. An early milestone is the demonstration that specific low-cost water soluble cationic surfactants can be strongly sorbed onto aquifer materials causing significant sorption of common groundwater contaminants. The ability of soil microorganisms to degrade contaminants in the presence of surfactant modified aquifer material is a second milestone. Success is demonstrated if the development of this technology is at the stage to enter into a field demonstration.

TECHNOLOGY TRANSITION PLAN: Following successful laboratory demonstration of the concept, a 6.3 field demonstration will be conducted. Technical reports will be shared with the R&D community. Laboratory experiments will be conducted in-house in preparation for the field demonstration. Design and cost guidance will be distributed to AF/DOD design agents employed with the remediation. Our MAJCOM and installations will be informed and updated through the technical data sheet process.

FUNDING ($K):

FY92	FY93
105	105

RESEARCH ACTIVITY: AFCESA/RA, Dr. David Burris, DSN 523-6007

RESEARCH TITLE: Zero Discharge Plan Development

OBJECTIVE: Develop a planning document to direct Air Force activities leading to the goal of zero discharge of hazardous waste to the environment by the Air Force Logistics Centers (ALCs).

- General Problem Statement. The Air Force operates five ALCs tasked with maintaining the readiness of most major Air Force weapon systems. A plan providing an organized, systematic method to establish research, development, demonstration, testing, and evaluation activities in support of waste minimization in ALC operations is needed to ensure optimum allocation of scarce resources.

- Limitations/Restrictions of Current Technology. Current and proposed regulations necessitate developing new technologies to meet environmental quality needs. Collaborative efforts with DOD, federal, and industry laboratories will be required to meet regulatory deadlines and leverage R&D funding.

BENEFITS: The plan will provide sufficient lead time to acquire, direct, and manage resources in the most efficient manner. Integration of the plan with other federal agencies will be undertaken to coordinate efforts, pool resources, and in other ways, take maximum advantage of resource leveraging for maximum benefit.

REQUIREMENTS: Program Action Directive 90-1, Hazardous Materials Integrated Management Program, Jan 90, HQ USAF.

- User/Sponsor. Air Force Materiel Command and ALCs

- Advocates/Supporters. USAF/CEV supports this effort since it provides essential input to the Environmental Quality Strategic Plan.

TECHNICAL APPROACH:

Phase I
Validate existing Zero Discharge Plan
Develop baseline waste minimization needs
Perform cost/benefit analysis for each of the target areas
Develop total RDT&E program cost estimate

Phase II:
Develop roadmap from complete analysis of ALC needs
Develop presentation material
Generate comprehensive report detailing completed effort

- Methodology/Approach Used to Perform Tasks. Phase I activities will involve verification and validation of the existing Zero Discharge Plan, updating the Plan, and making the Plan presentable to a variety of audiences. Phase II will provide greater detail concerning: the needs of ALCs, a detailed breakdown of realizable cost benefits attributable to the waste minimization effort, a complete analysis and a roadmap on a computer database system, a

summary on integration with DOE-OTD RDT&E programs, and a strategy for cooperative efforts and leveraged activities.

- Deliverable Requirement. Final Zero Discharge Plan with accompanying documentation. Complete set briefing materials to make Plan a useful tool for Air Force management.

- Description of Tasks Funded by Other Agencies. None.

TECHNOLOGY ASSESSMENT:

- Milestones/Experiments Used to Demonstrate Success.

Complete Phase I	May 92
Complete Phase II	Sep 92

FUNDING ($K):

FY92

500

RESEARCH ACTIVITY: AFCESA/RA, CPT Wayne Chepren, DSN 523-6007.

RESEARCH TITLE: Enhanced Anaerobic Degradation of Jet Fuels in Groundwater

OBJECTIVE: The objective for this project is to confirm anaerobic degradation of JP-4 jet fuel in laboratory column experiments. From these experiments, new methods could be developed to enhance in situ anaerobic degradation through addition of nutrients.

- General Problem Statement. The Air Force has documented over 1,000 fuel spill sites requiring some form of decontamination or monitoring.

- Limitations/Restrictions of Current Technology. Pump and treat technology alone is economically impractical for renovating aquifers contaminated with large quantities of fuel since the dynamics of immiscible flow result in prohibitively long time periods for complete removal of organic phase compounds. The slow release mechanisms of aromatic hydrocarbons, which are relatively water soluble, serve also as a slow release mechanism in sustained groundwater contamination. In situ enhanced biodegradation is often recommended as a cleanup method. However, HQ AFCESA and EPA researchers have documented many problems with current aerobic degradation methods, including high costs. To date, the in situ biodegradation of fuel has been limited to aerobic processes which require large amounts of oxygen be provided to the subsurface to stimulate biological activity. Homogeneous transfer of oxygen is seldom achieved and this process can be very expensive when oxygen sources such as hydrogen peroxide are used. A number of these deficiencies were documented in a recent field test at Eglin AFB.

BENEFITS: According to EPA studies, anaerobic degradation of jet fuel hydrocarbon components may proceed at faster rates than previously thought possible. If biodegradation can be improved without the addition of oxygen, future contaminated site remediations will be simpler and less expensive.

REQUIREMENTS: SAC-SON 04-82, "Groundwater Pollution Abatement." Also IRP Site Investigation Reports throughout the Air Force.

- User/Sponsor. The research will provide MAJCOM engineers and their consultants data to prepare and conduct feasibility studies for remedial action plans.

- Advocates/Supporters. HQ USAF/CEV and HQ AFCEE are strong advocates.

- Deliverable Requirement. Optimized nutrient addition data to stimulate anaerobic biological decontamination processes will be documented in a technical report,

- Comments. The U.S. EPA Robert S. Kerr Environmental Research Laboratory is at the forefront of developing in situ nitrate enhancement technology. It is likely we will continue our collaboration with the RSKERL to conduct this research effort.

TECHNICAL APPROACH:

-Major Tasks. Two tasks are planned as follows:

(1) To conduct bench scale laboratory studies using contaminated aquifer material for the determination of natural and enhanced rates of anaerobic biodegradation of JP-4 jet fuel hydrocarbons; specifically benzene, toluene, and xylene (BTX).

(2) To apply the same bacteria stimulation techniques to a JP-4 jet fuel contaminated aquifer.

- Methodology/Approach. Aquifer material will be collected from a JP-4 fuel contaminated site to be used in the bench scale studies. The US EPA RSKERL has developed specialized coring device and anaerobic glovebox hood to maintain the integrity of contaminated core samples. The cores will be transported to the laboratory for bench scale testing of nutrient/nitrate enhancement of biodegradation of the JP-4 hydrocarbons. Upon successful completion of the laboratory studies, a pilot scale enhanced in situ bioremediation treatment system will be set up and operated at the contaminated field site. A recirculating groundwater enhancement system will be utilized. The degradation of the JP-4 hydrocarbons, specifically BTX, will be monitored over time, as well as nitrate levels and concentration of intermediates from microbial nitrate utilization.

- Description of Tasks Funded by Other Agencies. The US EPA RSKERL is currently being funded by HQ AFCESA to perform bench scale nitrate enhancement studies. Also, the RSKERL has internal funding to conduct research in this area.

TECHNOLOGY ASSESSMENT:

Determine field site/collect aquifer material.	Mar 92
Complete any additional site characterization.	Sep 92
Complete bench scale experiments.	Dec 92
Design field treatment system/purchase hardware.	Mar 93
Installation of field treatment system.	May 93
Complete testing of treatment system.	May 94
Final sampling.	Jul 94
Final report on design, operating & cost information.	Sep 94

TECHNOLOGY TRANSITION PLAN: Near-term products of this technology endeavor will be technical reports and professional publications to keep government R&D agencies and their contractors informed of our progress. Once the technology is validated, design and cost data will be distributed to the service agencies and their contractors. Also, technical data sheets will be submitted to the MAJCOMs. Following a successful demonstration, the operating data, cost information, and scale-up design criteria will be transferred to HQ AFCESA to plan and perform a full-scale demonstration.

FUNDING ($K):

FY92	FY93	FY94
200	300	200

RESEARCH ACTIVITY: AFCESA/RA, Ms. Alison Thomas, DSN 523-6007

RESEARCH TITLE: Enhanced Redox Biodegradation

OBJECTIVE: The concept is to take microorganisms that have been selected for biodegradation of a toxicant, isolate the DNA of the redox system responsible for the degradation, and clone it in organisms that would improve its utility for toxic waste cleanup or disposal. This improvement would involve increasing the efficiency of cloned redox systems by combining them with redox systems of host organisms that are more controllable, easy to reproduce, and better adapted for the environment of the detoxification process. These organisms could be captive in the process in which the toxicant is formed and must be detoxified before disposal or injected into a confined environment that has access to the toxicant. Today, organisms for biodegradation are naturally selected from toxic dump sites and the special requirements for their growth must be satisfied to take advantage of their ability to detoxify whether the requirements are related to the detoxification or not. Examples are the requirement for complete aerobic conditions, low pH, limited growth rate in the toxic environment, or production of other undesirable chemicals. What is new in the approach is the hybridization of redox systems of different species of organisms. It will be successful because we have already demonstrated feasibility with a hybrid nitrate reductase system from the barley plant and mammalian white blood cells or E. coli. This is an extreme case of redox system hybridization, but dramatically demonstrates the feasibility of the approach.

BENEFITS: This technology will increase the efficiency of biodegradation and allow for detoxification as part of the manufacturing process. Furthermore, the redox chains we have already investigated can self-label and self-destruct the organisms so that they can be located and limited in whatever environment in which they are used. The former property allows users to avoid future pollution and the latter properties allow for a high level of quality control on the detoxification process.

PARTNERS AND RELATED ACTIVITIES: AFOSR has sponsored basic research with recombinant microorganisms for the purposes of detoxification and self-limiting growth. We have had discussions with Dr. Jim Cornette at HQ AFESC/RDV, Tyndall AFB, Florida, about using microorganisms isolated at this laboratory from toxic waste dumps as sources for DNA to be used in construction of hybrid redox systems. Pacific Northwest Laboratory (DOE) at Richland, Washington, is also isolating natural detoxifying organisms and considering the idea of monitoring luminescence in underground toxic sites to follow the progress of growth and kinetics of detoxification by recombinant (DNA) luminescent microorganisms. The instrument that would be used to monitor these organisms was jointly invented by personnel at the Armstrong Laboratory and PNL (the Quantitative Luminescence Imaging System, U.S. Patent 5,003,050). No Cooperative R&D Agreements are currently in place.

MILESTONES: The first examples of this technology would involved the isolation and cloning of DNA from Vibrio dechlorinations for the redox chain that detoxifies ammonium perchalorate. This chain would be hybridized with aerobic nitrate reductase of some appropriate aerobic organism such as E. coli. The isolation and cloning would take the first 6 months of the project (FY92) and the successful redox hybridization would require an additional 6 months to a year (FY 92 - 93). Upon completion of development of the prototype recombinant hybrid redox system, the program would be broadened for the development of other detoxifying recombinants, at an annual level of effort of two post-doctoral scientists and two technicians.

FUNDING ($K):

FY92	FY93	FY94	FY95
400	400	400	400

RESEARCH ACTIVITY: AL/OED, Dr. Johnathan L. Kiel, DSN 240-3583.

RESEARCH TITLE: Development of Spray Casting as an Alternative for Electroplating

OBJECTIVE: Demonstrate, at the pilot-scale, spray casting as a replacement for chromium electroplating. Determine the technical, economical, and environmental advantages of suing spray casting to replace electroplating processes.

- General Problem Statement. Conventional electroplating processes result in large quantities of rinse water and used electroplating baths. Treatment of these wastes results in the generation of large quantities of hazardous waste requiring costly disposal at an approved hazardous waste disposal facility.

- Limitation/Restriction of Current Technology. Conventional electroplating technologies are limited to those metals with convenient electrochemical potential. Electroplating technology results in large quantities of heavy metal contaminated sludges and rinse waters which must be treated. Treatment to remove these heavy metals is typically performed at the IWTP facilities. Large volumes of chemicals are used in the treatment and give rise to the generation of even larger volumes of hazardous waste sludge. The mixed metal sludges are nonamenable to economic metals recovery with current technology and must be disposed of in landfills. Near term modifications in RCRA regulations will make this increasingly unattractive as liabilities are directed back at the waste generators.

BENEFITS: The spray-casting process is expected to produce a process that can eliminate many "bath" type electroplating processes, eliminate the need for hazardous chemicals in the work environment, eliminate the hazardous waste clean up as a result of the electroplating processes now used, and reduce production costs by reducing coating times and chemical and hazardous waste disposal costs. A base such as Tinker AFB has potential savings of over $500K/yr. The process will enable the Air Force to economically meet current and future compliance requirements for metals treatment. Also, the process will result in the ability to more readily meet proposed hazardous waste minimization goals. This process will be applicable to other DoD, DOE, and industrial organizations.

REQUIREMENTS: Program Action Directive 90-1, Hazardous Materials Integrated Management Program, Jan 90, HQ USAF. This project also supports the HQ AFLC 29 May 86 Letter of Need, Hazardous Waste Reduction.

- User/Sponsor. Air Force Materiel Command and DOD maintenance organizations will use this technology. This process could also be used to replace electroplating operations required in GOCO operations.

- Advocates/Supporters. The Pacer Reduce/Pacer Impact Group in AFLC has expressed strong advocacy. OC-ALC/EME has also expressed strong support.

- Comments. This research is being coordinated with OC-ALC/EME, and DOE to design, construct, test, and evaluate a pilot-scale spray-casting unit as a replacement for selected chromium electroplating operations at Tinker AFB.

TECHNICAL APPROACH:

- Major Tasks of Effort. Collaborate with Boeing, OC-ALC/EME, and DOE to design, construct, test, and evaluate a pilot-scale spray-casting unit as a replacement for selected chromium electroplating operations at Tinker AFB.

- Methodology/Approach Used to Perform Tasks. Spray-casting is a process in which molten metal is aspirated into the gas stream by the Bernoulli principle where it is broken into fine droplets and sprayed onto the surface to be plated. The size, temperature, velocity and droplet concentration can be controlled by varying the operating parameters (ie. gas temperature, supply pressure, and melt temperature). The droplets are partially cooled in flight and compacted against a base metal to form a thin coating. This process differs significantly from plasma spraying, a process that has previously been determined inadequate for waste minimization purposes (See ESL TR 57-45). The spray casting process eliminates such problems as porosity and the high temperatures associated with the plasma spray process. Recent studies have shown the spray casting process to be technically feasible.

- Deliverable Requirement. A final report detailing results, economics, the design of a unit for field testing will result from this effort.

- Description of Tasks Funded by Other Agencies. OC-ALC/EM, REPTECH, and Boeing Aerospace Corp are expected to provide collaberative funding for this effort but the extent will not be known until late 1992.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used To Demonstrate Success

Spray selected Air Force parts with chromium	FY 92
Validate chrome coating against applicable specifications	FY'92

TECHNOLOGY TRANSITION PLAN: This project will be followed by a field demonstration of spray-casting at a host ALC.

FUNDING ($K):

FY92

650

RESEARCH ACTIVITY: AFCESA/RA, Lt. Philip Brown, DSN 523-6007

RESEARCH TITLE: Enhanced Abiotic Degradation of Groundwater Contaminants

OBJECTIVE: Determine abiotic oxidation and reduction reactions of contaminants which may be enhanced in the subsurface environment. Evaluate methods which may be used to enhance these abiotic degradation relations in the subsurface.

- General Problem Statement. Discharges of jet fuel and solvents to subsurface environments has led to contamination of groundwater resources. Cost-effective remedial alternatives for contaminated groundwater must be explored.

- Limitations/Restrictions of Current Technology. The current common practice is to pump the contaminated groundwater and treat it above ground. This has proven to be expensive due to capital costs, maintenance, and the long time required for aquifer cleanup. Engineering a suitable environment in situ to enhance aerobic biodegradation of contaminants in the water saturated subsurface has generally proven difficult. Contaminant source cleanup technologies generally leave sufficient residual contamination to require additional groundwater remediation efforts. Remediation of sites contaminated with dense nonaqueous phase liquids has proven difficult due to their ability to sink below the water table, thus preventing effective source cleanup.

BENEFITS: The technology could provide a cost-effective remedial alternative for Air Force groundwater contamination sites and reduce the associated liability.

REQUIREMENTS: This project supports SAC SON 04-82. The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The problem of fuel and solvent contaminated groundwater has been well documented in IRP Information Management System site investigation reports.

- User/Sponsor. The IRP, MAJCOMs, contractors, and civilian environmental engineering community will use/sponsor this technology.

- Advocates/Supporters. AF/CEV, AFCEE, and MAJCOM/DEVs are the advocates.

- Deliverable Requirement. The principal deliverable is a detailed evaluation of the potential to enhance abiotic degradation reactions insitu. All experimental designs, results and data interpretations will be documented in peer-reviewed publications and/or a final report.

- Comments. This effort is a follow-on to "In Situ Contaminant Mobility Reduction using Surfactants" and Reduction of Chlorinated Organics in Groundwater".

TECHNICAL APPROACH:

- Major Tasks of Effort. Determine potential oxidizing and reducing agents. Evaluate potential methods for emplacing the redox agents in aquifers. Evaluate conditions necessary to promote electron transfer between the redox agents and groundwater contaminants, as well as those necessary to regenerate the redox agents. Evaluate potential methods for establishing the necessary conditions in situ for abiotic degradation reactions to occur.

- Methodology/Approach Used to Perform Tasks. Laboratory research will concentrate on metal porphyrins as oxidizing and reducing agents, although others may be considered. Emphasis will be placed on anoxic systems since oxygen is generally depleted in contaminated aquifers. Methods for introducing the porphyrins to the subsurface will be explored. Emphasis will be placed on the use of cationic surfactants or cationic porphyrins. Methods to engineer the necessary conditions in the subsurface which will not adversely affect groundwater quality will be examined. Degradation of several common groundwater contaminants of Air Force concern will be examined and their degradation products determine. Emphasis will be placed on reduction of the chlorinated solvents, TCE and PCE.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success

FY93 - Emplacement to demonstrate success.
FY94 - Establish that suitable reaction kinetics can be obtained.
FY95 - Assess various emplacement method/redox agent pairs.

TECHNOLOGY TRANSITION PLAN: A 6.2 project will follow this effort to optimize a suitable redox agent/emplacement method system. A 6.3 field demonstration will follow and utilize that system. Assuming success of the 6.3 efforts, further transition to the field will be coordinated with AFCEE and AFCESA program offices.

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
160	200	225	90	675

RESEARCH ACTIVITY: AFCESA/RA, Dr. David Burris, DSN 523-6007

RESEARCH TITLE: Demonstration of Low-Temperature Plastic Media Blasting Waste Treatment

OBJECTIVE: Pilot demonstration of the effectiveness of low-temperature ashing to reduce plastic media blasting (PMB) hazardous waste by 95 percent.

- General Problem Statement. Depainting of aircraft by chemical stripping generates a large volume of hazardous waste that presents an economic and environmental burden. PMB is an alternative paint stripping method that eliminates the generation of hazardous liquid waste. This process, however, generates large volumes of solid hazardous waste.

- Limitations/Restrictions of Current Technology. PMB to remove paint from Air Force aircraft and paint produces a waste which exceeds the Environmental Protection Agency (EPA) extraction procedure toxicity level of chromium such that the waste is classified as hazardous. Currently, PMB waste must be disposed of as hazardous waste. The disposal cost is approximately $1,000 per ton.

BENEFITS: Installations conducting paint stripping operations benefit from the rapid paint stripping capability of the PMB process. The success of the low-temperature ashing waste treatment process will reduce the hazardous waste volume by 95 percent.

REQUIREMENTS: Program Action Directive 90-1, Hazardous Materials Integrated Management Program, Jan 90, HQ USAF. This project also supports the following Letters of Need: OO-ALC/MABE, 19 Mar 85; HQ AFLC, 29 May 86; OO-ALC/MAQVE, 3 Feb 89.

- User/Sponsor. HQ Air Force Materiel Command.

- Advocates/Supporters. SA-ALC/MAQ/MABEB, PACER IMPACT Group, JDMAG, and HQ AFLC/MAQ.

- Comments. This research is being coordinated with the DOD PMB Working Group, OO-ALC, AFLC, and WL/MLSE.

TECHNICAL APPROACH:

- Major Tasks of Effort. Spent PMB media will be treated to determine the effectiveness of the low temperature ashing process. The associated processes to be developed for this system include the following: pelletization, ashing, solidification, and stabilization processes. Potential Air Force savings in used media disposal costs will also be determined.

- Methodology/Approach Used to Perform Tasks. Key areas to be evaluated during this pilot study include: dust control for the pelletization process, controlled oxidation of low-temperature ashing, off-gas control, and the performance of the solidified compact.

- Deliverable Requirement. A complete design for a full-scale prototype system will result from this effort.

- Description of Tasks Funded by Other Agencies. None.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments used to demonstrate success:

Waste disposal statutes and background information review	DOA + 1 month
Complete economic analysis	DOA + 8 months
Complete pilot plant studies	DOA + 14 months
Complete full-scale design	DOA + 16 months
Complete final technical report	DOA + 18 months

TECHNOLOGY TRANSITION PLAN: Following a successful demonstration, a follow-on 6.4 effort will develop the appropriate procurement specifications required by DOD users. A detailed estimate of funding required for Air Force-wide implementation will be developed at the conclusion of the present effort.

FUNDING ($K):

FY92	FY93
350	500

RESEARCH ACTIVITY: AFCESA/RA, Mr. David Pipkin, DSN 523-6007

RESEARCH TITLE: Toxicology

OBJECTIVE: To provide the technological support required to implement the Air Force Pollution Prevention Program. The program requires the minimization or elimination of hazardous materials currently used or planned for use by the Air Force. This requires development of alternate or substitute materials and processes. These proposed alternatives must be evaluated for their toxicological properties to determine whether their proposed use may be more environmentally or occupationally hazardous than the material they are intended to replace.

APPROACH: Safety testing and screening of potential replacement chemicals and comparisons with existing materials will be accomplished using novel in vitro and classical testing approaches. The effort will be in conjunction with materials process development at the Materials Laboratory and other laboratories and program offices. It involves preliminary screening of candidate materials, research of commercial data sources, and, if required, more indepth hazardous property testing. Both inhouse and contract testing could be required depending on the customer demand. There is a shortfall of $859K in FY92 to maintain the current level of investigations of materials. Based on the implementation of the Pollution Prevention Program, toxicological evaluations will increase in number and scope.

BENEFITS: Toxicological evaluations of current and proposed chemicals for Air Force use will provide the mandatory information to make intelligent trade-off decisions. Alternative materials may be discovered to be worse than what they replaced if the upfront evaluations are not made.

FUNDING ($K):

FY92	FY93	Cont.
1,000	1,000	1,000/yr

RESEARCH ACTIVITY: AL/OET, Col. Vermulen, DSN 785-3423

93

RESEARCH TITLE: Validation of Aphron Oxygen Enrichment of Subsurface

OBJECTIVE: Validate by field demonstration, the ability of aphrons (air or oxygen microbubbles) to support biodegradation of subsurface contamination cheaper and more efficiently than conventional subsurface oxygen enrichment techniques.

- General Problem Statement. Highly effective bioremediation techniques are being rapidly developed to destroy groundwater contamination under controlled reactor conditions. However, there are no developed engineering techniques to deliver nutrients to the subsurface, achieving continued bioavailablity for effective in situ remediation.

- Limitation/Restrictions of Current Technology. Conventional cleanup technologies involve pumping contaminated groundwater to the surface for treatment. However, the flushing process can take decades. In situ cleanup technologies take the treatment process to the source contamination. Enhanced aerobic biodegradation is theoretically effective for treating organics. Biodegradation rates are limited by the availability of oxygen. Sparked air and hydrogen peroxide have been used to supply oxygen to subsurface water. Air sparging can only supply low concentrations of oxygen. Hydrogen peroxide is expensive. It also tends to degrade so rapidly in an aquifer that oxygen is lost from solution if hydrogen peroxide concentrations exceed 100 ppm. In addition, iron precipitation problems associated with these techniques have not been overcome, limiting our ability to disperse nutrients throughout the area of subsurface contamination.

BENEFITS: Colloidal gas aphrons are a stable emulsion of air in water. Therefore, a higher mass loading of oxygen can be supplied to groundwater without being limited by solubility of air in water. In addition, aphrons are less expensive and much less reactive than hydrogen peroxide. Earlier efforts indicate that when aphrons are injected into the subsurface, they are caught up in the surrounding soil. Water passing through the "aphron zone" acquires dissolved oxygen from the microbubbles. This approach should be cheaper and more efficient than sparked air or hydrogen peroxide. Recent laboratory pilot-scale experiments have demonstrated much higher oxygen levels in flowing groundwater downstream from the aphron zone than is achievable by air sparging or hydrogen peroxide. In addition, aphron oxygen remains in the soil matrix for extended periods of time, allowing continued oxygen transfer to the groundwater. No other technology provides this level of efficiency. This effort will validate the technology in a realistic field situation.

REQUIREMENTS: This project directly supports SAC SON 04-82, Groundwater Pollution Abatement. It also addresses a problem statement in the Environmental Quality R&D Strategic Plan entitled, "Improved Method for Remediation of Contaminated Soil, Including Soil Beneath Existing Structures."

- User/Sponsor. MAJCOM and base-level engineers and their contractors will use this technology to design and implement groundwater treatment systems for site remediation.

- Advocates/Supporters. AF/CEV, AFCEE, and EPA all support and advocate this technology development.

- Deliverable Requirement. The principal deliverable will be full-scale design criteria for a complete groundwater remediation system using in situ aphron injection. A technical report will detail a full technical and cost analysis of the technology in comparison to existing remediation techniques.

- Comments. The technology will likely produce patentable equipment design for aphron generation and also produce commercial licensing which will precede full-scale application.

TECHNICAL APPROACH:

- Major Tasks of Effort. A pilot, field-scale aphron generation and injection system will be designed and installed at an actual well-characterized contaminated site. Performance effectiveness, cost, and optimum operating parameters will be determined.

- Methodology/Approach Used to Perform Tasks. Aphron generation equipment has been developed and is being refined in a current 6.2 effort. Pilot laboratory-scale test have been performed examining various injection strategies. Optimum injection hardware will be designed and installed at the field site, most likely in a trench system to create an aphron zone through which the groundwater will pass. Monitoring wells installed upstream and downstream will measure oxygen uptake and contaminant degradation. Study of varying operating parameters will take place over 18 months. A cost analysis will also be performed.

- Description of Tasks Funded by Other Agencies. EPA has co-funded the 6.2 effort with the Air Force. Both EPA and DOE are potential partners in 6.3.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success.

Detailed engineering field design with regulatory permitting in place. Jun 92

Demonstration of 95 percent remediation at 25 percent less cost than existing groundwater treatment techniques. Jun 94

The 6.2 work is near completion. This project is scheduled for an FY 92 start.

TECHNOLOGY TRANSITION PLAN: Following successful demonstration, initial technical results and cost data will be distributed in the form of tech data sheets to MAJCOMs and bases and in the form of peer reviewed publications to the R&D community. One or two follow-on field efforts will be planned with AFCEE to further validate the technology in different and more challenging field conditions. These field demonstrations would take place at IRP sites with substantial user funding. Design packages will then be distributed to Air Force design agents. Widespread full-scale implementation will depend on commercial development with definition of full-scale design, operation, and maintenance factors by the AFCESA System Program Office.

FUNDING ($K):

FY92	FY93	FY94
300	500	400

RESEARCH ACTIVITY: AFCESA/RA, Capt. Catherine Vogel, DSN 523-6007

RESEARCH TITLE: Halon 1301 Aviation System Replacement

OBJECTIVE: Fire and explosion suppression agents used on military aircraft require strict performance criteria that demand lightweight, clean, nontoxic, and high performance qualities in suppression and dispersal. These agents are used in aircraft fuel tanks, surrounding compartments (dry bays) and engine nacelles for protection against peacetime and combat threats. Halon 1301 has been found in the past as the only feasible agent that meets these criteria sufficiently. Halon 1301 systems are currently installed in almost all military aircraft. However, Halon 1301 is a strong ozone depleter and will be phased out under the Montreal Protocol by FY2000. This program would screen candidate agents to replace Halon 1301 and test the best candidates in the dry bay and engine nacelle applications.

APPROACH: The program will begin by determining the requirements the Halon replacement must meet in the areas of fire suppression capability, corrosivity, conductivity, material compatibility, shelf life, and toxicity. These requirements must be developed since standard design practice has been to use Halon 1301, so specific requirements have not been established. Controlled studies and test evaluating agent dispersion and transport characteristics will be performed, followed by full-scale testing. The best 2 to 3 candidate agents will proceed to comprehensive testing. Candidate agents will be evaluated for compatibility with existing hardware, corrosiveness, electrical conductivity, combustion by-products and their resulting effects, and issues related to logistics and support ability. Toxicity studies will be performed as part of this effort. Renovation of Air Force unique test facilities to support the performance testing will also be required under this program. The final phase of the program will be to produce the necessary design criteria and equations to adequately design systems (both current and future) to successfully use the selected agent(s) in applications.

BENEFITS: A recent ASD study has shown a savings of $760 million in USAF aircraft assets due to fire loss prevention from Halon 1301 systems over the last 14 years. This program is to provide a mission essential capability for fire protection with minimal system impact and proven substantial benefits in asset preservation due to fire loss.

PARTNERS AND RELATED ACTIVITIES: The Federal Aviation Administration is coordinating their requirements to this proposed program and will expand these results to include large cargo bay experiments and qualifications. Chemical companies are exploring the new market for CFC and Halon alternatives. This program will include support from the Naval Research Laboratory in agent screening and the National Institute of Standards and Technology. Suppression system manufacturers are performing limited tests to assess the impact of replacement agents on their systems.

MILESTONES:

Program start	Jan 92
Test facility renovation	Sep 92
Laboratory scale screening	Sep 93
Agent/systems compatibility	Sep 93
Toxicity, env. impact, supportability	Sep 94
Design criteria tests	Sep 95

FUNDING ($K):

FY92
300

RESEARCH ACTIVITY: WL/FIVS, J. Michael Bennett, DSN 785-6302

RESEARCH TITLE: Halon 1301 Facility Total Flood Agent Replacement Program

OBJECTIVE: Eliminate USAF inventory of ozone-depleting Halon 1301 fire extinguishment agent used in facility total-flooded suppression systems to protect high-value electronic systems. Replace Halon 1301 with an environmentally-safe chemical with low toxicity and compatability with existing installed systems. Research responds to HQ AFSPACECOM 009-90 SON, Replacement for Halogenated Fire Extinguishing Agent 1301.

APPROACH: The on-going AFCESA RDT&E program has developed a low ozone depletion potential (ODP) replacement chemical blend for Halon 1211, the DOD streaming agent for flight line extinguishes. This research screened a large inventory of chemicals on the basis of fire extinguishment potential, low ODP, toxicity, cost and availability, and identified several Halon 1301 replacement candidates in the process. The technical approach to develop and validate a replacement Halon 1301 extinguishing agent will require a 5-year program and consists of the following major research units: (1) laboratory-, small-, and medium-scale testing to determine fire extinguishment performance and agent flow characteristics and compatibility with existing installed systems; (2) toxicity evaluations based on previous and on-going study results; (3) combustion by-products analysis; (4) facility occupant exposure analysis; (5) materials compatibility/cleanliness determination; (6) environmental impact analysis; and (7) logistics and production specification development.

BENEFITS: Protection of mission critical computer and electronics systems supporting NORAD and all warfighting commanders in chief with a very low or non-zone depleting agent. Insures USAF compliance with DODD 6050.9, AFR 19-15, which will prohibit USAF use of all Halon firefighting agents after January 2000, the 1990 Clean Air Act, and the Montreal Protocol.

PARTNERS AND RELATED ACTIVITIES: ASD (WR/FI) development of Halon 1301 replacement for engine nacelle and dry bay compartment aircraft systems. U.S. Naval Research Laboratory (NRL) and U.S. Army Tank and Automative Command (TACOM) requirements for developing shipboard and armored vehicle Halon 1301 replacements.

MILESTONES:

Agent development and initial testing (6.2)	FY92-FY93
Agent performance/toxicity validation, environmental assessment and production specification (6.3A)	FY93-FY95
Production contract and availability to DOD users	FY96

FUNDING ($K):

FY92	FY93	FY94	TOTAL
400	900	400	1,700

RESEARCH ACTIVITY: HQ AFCESA/RAC, Capt. John Floden, DSN 523-3734

RESEARCH TITLE: Non-Toxic/Non-Hazardous Surface Preparation s for Aluminum (Al) and Titanium (Ti) Structural Alloys

OBJECTIVE: To develop surface preparations for Al and Ti alloys used in aerospace vehicles that do not depend on the use of large amounts of water and toxic or hazardous materials such as hexavalent chromium, strong oxidizing acids or concentrated bases in order to reduce to practical minimums or completely eliminate hazardous and toxic waste.

APPROACH: This program will involve laboratory R&D process scale-up, specifications development, and technology transition in two major areas:

(1) Laser surface preparation of Al and Ti alloys. The feasibility of the use of the excimer laser to grow oxides on Al has been shown, and bondability to both coatings and adhesives has been demonstrated.

(2) Nonchemical surface preparation methodology. R&D work has demonstrated that the correct surface morphologies for coating and bonding to Al, Ti, and Copper (Cu) can be achieved via nonchemistry-gassed processes including plasma spray, flame spray, and vapor deposition.

The above approaches are based on new technology and initial feasibility has been demonstrated. Today's processes are based on wet chemistry and require soluble chromates, strong acides and bases, and large amounts of water. The result is hazardous and toxic waste streams that are increasingly expensive to satisfactorily treat. The new approaches represent a radical depature from existing technology. There are no serious technological roadblocks foreseen in the scale-up of these processes.

BENEFITS: The successful transition of this technology to the Air Logistics Centers (ALCs) will result in the elimination of a significant portion of their wastewater stream that must be treated to remove chrome, acids and bases. The new processes will be environmentally acceptable and will produce no toxic or hazardous waste. The private sector will be able to realize the same benefits by exploiting this technology.

PARTNERS AND RELATED ACTIVITIES: There are no other DoD or Federal agencies working the specific technology areas proposed. The private industry has no published projectes in the proposed technology areas. The establishment of CRDAs with the private sector will be pursued. ALC partners interested in participating and evaluating this technology will be sought.

MILESTONES:

FY92 - Initiate contractral R&D in the technology areas. Establish relationships with ALC customers and CRDA agreements with the private sector.

FY93 - Complete process optimization and process parameter sensitivity determinations.

FY94 - Scale-up and debug processes and develop materials, processes, and manufacturing specifications.

FY95 - Transition processes to ALC customer and assist CRDA partners in exploiting the technology.

FUNDING ($K):

FY92	FY93	FY94	FY95
100	400	500	1,000

RESEARCH ACTIVITY: WL/MLSE, J. J. Mazza, DSN 785-7483

RESEARCH TITLE: Crossflow Air Stripping with Catalytic Oxidation

OBJECTIVE: Field demonstrate crossflow air stripping and catalytic oxidation as cost-effective treatment technologies for cleanup of contaminated groundwater.

- General Problem Statement. Estimates, based on the Installation Restoration Program Information Management System (IRPIMS), indicate that over half of the Air Force bases have groundwater contaminated with organic compounds above the drinking water limits.

- Limitations/Restrictions of Current Technology. A typical groundwater treatment system for VOCs consists of a countercurrent air-stripping tower and an activated carbon adsorption system for emissions control. These technologies have their disadvantages. In the countercurrent tower, energy required for the blower to strip the contaminants can constitute a majority of the operating costs. With activated carbon adsorption, the contaminant is merely transferred from the air to the activated carbon. The contaminant must then be removed from the carbon and destroyed. This regeneration process is extremely expensive.

BENEFITS: Crossflow air stripping will enable engineers responsible for IRP groundwater cleanups to remedy contamination problems in a cost-effective and efficient manner. A crossflow air stripper will reduce blower operating costs. Catalytic oxidation systems will completely destroy contaminants rather than transferring them to another media.

REQUIREMENTS: SAC SON 04-82, the Environmental Quality R&D Strategic Plan, and the Remedial Investigations.

- User/Sponsor. IRP managers and engineers at each base.

- Advocates/Supporters. AF/CEV and AFCEE are advocates.

- Deliverable Requirements. Operation and maintenance plan, quality assurance project plan, site safety plan, A/E services during construction, design manuals for crossflow air-stripping towers and catalytic oxidation systems, technology summary sheets, and final report.

TECHNICAL APPROACH:

- Major Tasks of Efforts. Design, construct, and operate a crossflow air stripper with catalytic oxidation emissions control. Compare operation of this process to conventional countercurrent air stripping. Produce required documentation.

- Methodology/Approach Used to Perform Tasks. Operational testing of the unit will be such that the scale up factors and overall performance of this new technology can be determined. The performance of the crossflow unit will be compared to conventional countercurrent air stripping tested at the same site under the same conditions. Parameter testing will determine the range and scope of application of this new technology as it operates in the field.

- Description of Tasks Funded by Other Agencies. An emerging technology developed by EPA for emissions control using electric arc (also known as corona destruction) will also be demonstrated on-site. EPA will provide the hardware for the tests.

MILESTONES/EXPERIMENTS USED TO DEMONSTRATE SUCCESS:

Complete site permitting process	May 92
Construct/install strippers and begin operations	Jun 92
Initial tech data sheet completed	Jul 92
Long-term field tests completed	Mar 93
Final tech data sheet completed	Apr 93
Final report/design specificating	Sep 93

TECHNOLOGY TRANSITION PLAN: The design package will allow this technology to transition directly to the field to be used in feasibility studies by AFCEE and other IRP site restoration agencies. In addition, the results from the pilot-scale work will be published in a technical report and peer-reviewed journal articles. Design, cost and performance data would be forwarded, via Tech Data sheets and the design packages, to IRP engineers at the MAJCOM and base level.

FUNDING ($K):

FY92	FY93
650	500

RESEARCH ACTIVITY: AFCESA/RA, Capt. Ed Marchand, DSN 523-6007

RESEARCH TITLE: Minimal Treatment Option for JP-4 Contaminated Soil

OBJECTIVE: Determine the degree and time required for passive remediation at hydrocarbon fuel spill sites. The results from this study will allow prioritization of cleanup actions for contaminated sites. This will be a study of the potential for minimal treatment at a waste site.

- Limitations/Restrictions of Current Technology. The initial reaction to a spill is that something must be done. Pump-and-treat, air stripping, bioremediation, and soil venting are some of the methods that have been tried but are not 100-percent effective. They do not address long-term problems with the dilute aqueous phase.

- Payoff/Benefit to the Air Force. Data from the study will provide a sound and rational basis for assessing and managing groundwater contamination site cleanup. This data will also help us to establish what level of cleanup is necessary. A significant savings on remediation costs will be the final net result.

REQUIREMENTS: The Secretary of Defense is required by 10 USC 2702 to carry out a program of research, development, and demonstration with respect to hazardous waste. The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and field demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The remediation problems have been documented in IRP site investigation reports from throughout the Air Force.

- User/Sponsor. Generally, the scientific and engineering community will use these results to enhance the understanding of hydrophobic organic transport processes. Specifically, the Air Force and their remediation contractors will employ the information gained to more effectively make decisions regarding decontamination.

- Advocates. HQ USAF/CEV and AFCEE are the advocates.

- Comments. Cornell University, University of Florida, and the College of William and Mary have coordinated on this study.

TECHNICAL APPROACH:

- Major Tasks of Effort. Locate a field site that is not scheduled for immediate cleanup. Determine the extent of the jet fuel contamination. Remove as much of the liquid free product as possible. Institute a long-term surveillance of jet fuel components leaving the site in groundwater.

- Methodology/Approach Used to Perform Tasks. In many spill situations, there is no immediate danger to drinking water resources. (The free product should always be removed as soon as possible by conventional means). The long-term fate and chemical nature of the residual jet fuel left on the soil is unknown. This study concerning the in situ aging of jet fuel will verify what residuals will actually remain on the soil. This information is particularly necessary for developing possible treatment techniques for sites

where spills have occurred in the more distant past. It is possible that many of the lighter components will be volatilized, leaving only heavier weight components that move slowly. The slowly moving components may have hydrolysis or biological breakdown rates that would remove them from the subsurface prior to endangering groundwater. Thus, minimal remediation action may be a viable alternative. This study will also provide baseline data for exposure assessment, showing effects of no treatment, and providing cost to benefit ratios of various treatment processes.

- Deliverable Requirement. A final report detailing all experimental findings and recommendations for the necessity of residual fuel cleanup.

- Description of Tasks Funded by Other Agencies. None.

TECHNOLOGY ASSESSMENT:

- Milestones/Experiments Used to Demonstrate Success. The midterm is the successful design, fabrication, and validation of bench-scale experimental apparatus. The final exam is demonstration that passive remediation is a significant factor in fuel spill cleanup (i.e. greater than 70 percent of the JP-4 contamination will not cause future health or environmental problems).

TECHNOLOGY TRANSITION PLAN: Following completion of the study, peer-reviewed scientific papers will be published to inform the scientific and engineering community of the findings. If significant degradation occurs, the necessity of treating water at JP-4 contamination sites must be reevaluated, and passive remediation will be considered in expert systems analysis techniques such as Remedial Action Cost Estimating and Requirements (RACER).

FUNDING ($K):

FY92	FY93
250	250

RESEARCH ACTIVITY: AFCESE/RA, Dr. Stauffer, DSN 523-6007

RESEARCH TITLE: Alternative Solvents/Technologies for Paint Stripping

OBJECTIVE: Evaluate ability of commercially available chemical paint strippers to satisfy Air Force requirements. Stripper performance enhancement and waste treatment techniques will also be examined.

- General Problem Statement. Current paint strippers contain methylene chloride, phenol, formic acid, and sodium chromate which are toxic and generate hazardous wastes. These strippers have been proven toxic to humans even at low levels of exposure. Control equipment is required to capture vapors resulting from use of these solvents. Large quantities of paint stripping waste are generated requiring disposal as a RCRA waste for which the Air Force maintains liability in perpetuity.

- Limitations/Restrictions of Current Technology. Conventional paint stripping processes use large volumes of toxic chemicals to strip paint from military hardware. This results in the generation of large quantities of hazardous waste requiring expensive disposal. In addition, worker safety is jeopardized by constant exposure to these toxic chemicals.

BENEFITS: An optimized chemical/mechanical paint stripping system will be provided which will combine efficiency, economics, and environmental benefits. Hazardous waste generation from chemical paint strippers will be minimized and environmental constraints will no longer prevent continuation of mission goals.

REQUIREMENTS: Program Action Directive 90-1, Hazardous Materials Integrated Management Program, January 1990, HQ USAF. This project also supports the HQ AFLC 19 May 1986 Letter of Need, Hazardous Waste Reduction.

- User/Sponsor. Air Force Materiel Command and DoD maintenance organizations will use this technology.

- Advocates/Supporters. OC-ALC/EM has expressed support for this effort.

TECHNICAL APPROACH:

- Major Tasks of Effort. Testing will be performed to determine the most effective, nonhazardous, and nontoxic chemical/mechanical paint stripping methods currently commercially available.

- Methodology/Approach Used to Perform Tasks. A Phase I stripper screening program was funded and performed by DOE - Idaho National Engineering Laboratory to evaluate candidate chemical strippers against Air Force requirements. Strippers passing Phase I will be evaluated for efficiency, life expectancy, capacity, and irremissibility. Actual aircraft parts will be used in testing. Parts will be repainted to determine refinishing properties of the stripped surface. Extended corrosion tests will also be performed. Possible process techniques to enhance the stripping efficiency of the alternative paint strippers will be identified and evaluated.

- **Deliverable Requirement.** A final technical report providing design guidance for application of alternative paint strippers. A draft guideline standard will also be developed as a means of communicating Air Force requirements for alternative paint strippers to industry to encourage independent development of additional alternative strippers for Air Force application.

- **Description of Tasks Funded by Other Agencies.** None.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success:

Treatability Studies	March 1992
Pilot-scale testing	March 1992-September 1992
Testing at Tinker AFB	October 1992-September 1993

TECHNOLOGY TRANSITION PLAN: A 6.4 follow on will provide full-scale demonstration of resulting technology.

FUNDING ($K):

FY92	FY93
300	905

RESEARCH ACTIVITY: AFCESA/RA, Mr. David Pipkin, DSN 523-6007.

RESEARCH TITLE: Improved Hydrocarbon Remediation Monitoring

OBJECTIVE: The overall objective of this project is to develop and evaluate methods to monitor the groundwater and vadose zones to measure the amount of remediation being achieved. To advance the development and evaluation of techniques for the detection, quantification, and determination of remediation rates at Air Force sites contaminated by hydrocarbons. The suitable methods of monitoring should be economical and should result in the reduction of manpower required to collect samples and perform analysis. Emphasis shall be placed on methods which allow in situ, real-time monitoring or easy sampling with field analysis and will first target bioremediation monitoring.

There are almost 4,300 contaminated Air Force sites with an anticipated cleanup and monitoring cost of over $5 billion. The Air Force has documented over 1,000 fuel-spill sites requiring some form of remediation or monitoring. The number of sites will increase with the stricter regulation of the Air Force's 35,000 underground storage tanks. In situ biodegradation is frequently recommended as a remedial action. Problems with measuring biodegradation have been documented by Environmental Protection Agency (EPA) and HQ AFCESA researchers conducting enhanced biodegradation field studies.

APPROACH: This approach will evaluate available techniques and provide for development of new techniques for the detection of hydrocarbon contaminants. It will also determine rates of physical and natural or enhanced biodegradation. Initial emphasis will be on using soil gas monitoring and determining rates of remediation and biodegradation. Current sampling and analysis methods are focused on identifying both general and very specific types of contaminants. Emphasis has recently been placed on the difficult problem of soil and soil gas sampling, analysis, and correlation to contaminant concentration and amount of remediation occurring. While methods such as gas chromatography and mass spectrometry can detect low levels of individual hydrocarbons components, this usually requires sampling with laboratory analyses later. This research will develop protocols for using in situ monitoring devices or field sampling and analysis techniques for determining contaminant concentrations and proving when remediation is occurring.

BENEFITS: The Air Force's hazardous waste sites, many of which have hydrocarbon contamination, will require remediation and/or monitoring. Significant time and cost savings for site investigations will result from improved monitoring techniques. Soil vapor monitoring techniques will eliminate the need for many monitoring wells and aid in selecting appropriate locations for further monitoring. Soil vapor collection devices amy provide an inexpensive alternative for monitoring hazardous waste sites that have been well characterized. In situ treatment is potentially less expensive and is preferred over conventional treatment methods. The only way to improve processes is to have a method to monitor them. Determining the rates of remediation is critical to measuring the success of the remediation or for input into risk analysis models to show there is little hazard to the environment if the hydrocarbon contaminant is allowed to degrade naturally in place. A 10-percent improvement could mean great cost savings for active remediation. Active remediation may not be necessary if it is determined that

natural remediation is sufficient at reducing contaminant levels to an acceptable level of risk.

PARTNERS AND RELATED ACTIVITIES: The Environmental Protection Agency's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) and Robert S. Kerr Environmental Research Laboratory (RSKERL) in Ada, OK, shall perform this effort. They will perform research, development, demonstration, test, and evaluation of sensors and advanced monitoring techniques with potential for application at Air Force facilities. AFCEE and AF/CEV are potential advocates for this technology. Related activities include a number of monitoring and biodegradation efforts being conducted by AFCESA.

MILESTONES:

Field Site Selection and Instrument Evaluation. Report Results and Provide Interim Users Manual.	FY92

FUNDING ($K):

FY92
400

RESEARCH ACTIVITY: HQ AFCESA/RAVW, Mr. Bruce J. Nielsen, DSN 523-6011.

RESEARCH TITLE: Prototype VOC Monitor, Phase 3

OBJECTIVE: Develop and field an automatic analytical system that is operable by minimally skilled operators at a location on base and that will generate EPA-approved water-quality results within hours of sample collection.

APPROACH: Phases 1 and 2 have shown that commercial analytical hardware can be integrated into an automatic analyzer, and that EPA will issue alternate test procedure qualification to a system whose programming includes routines to perform appropriate quality assurance (QA) functions during calibration and data evaluation. Satisfactory proposals are in hand from several reliable sources that would be able to ensure long-term support for the final product, and that are prepared to offer complete annual contract support for a fixed, up-front fee.

BENEFITS: System will permit airman-level base personnel to perform same-day analyses of VOCs in water samples. These analyses will be acceptable as evidence of environmental regulatory compliance (or noncompliance). For unsatisfactory or suspect analyses, it will permit repeats during the same day from the same collection site. It will also allow the base to budget a fixed front-end amount that will provide for all of the analyses that will be needed during the year.

PARTNERS AND RELATED ACTIVITIES: OO-ALC/EM and OC-ALC/EM are being approached as possible sources of partial support for this effort. Both ALCs are available as demonstration sites if another source of support is identified. The product is close enough to commercial development that no cooperative interaction is planned.

MILESTONES:

Award of contract	100 days after funds identified
Prototype into field	240 days after award of contract
Operator training/documentation	240 days AAC
Supported field evaluation	Through 600 days AAC
Final report	660 days AAC
Local ATPs from EPA	660 days AAC
Nationwide ATP	900 days AAC

FUNDING ($K):

FY92	FY93
203	200

RESEARCH ACTIVITY: HQ AFCESA/RAVS, Dr. Joseph D. Wander, DSN 523-6026.

RESEARCH TITLE: Pulsed Hydraulic Flushing

OBJECTIVE: Investigate the benefits, costs, and complications of pulsed pumping in delivery and recovery operations associated with remediation of contaminated groundwater.

- **Limitations/Restrictions of Current Technology.** Present pumping strategies for groundwater remediation typically involve continuous operation of an extraction/injection wellfield. Field observations of these strategies indicate that the contaminant concentration discharged by extraction wells declines with time to reach a long-term low concentration plateau. A very large volume of water is pumped to remove a relatively small amount of contaminant mass. Concentrations increase significantly once pumping is stopped. The reason for this behavior is that mass transfer limitations exist at the groundwater flow rates used during remediation (i.e. equilibrium conditions are not established). The size of the aboveground treatment system is dependent upon the volume of water it has to treat. Some treatment systems such as bioreactors tend to require moderately high concentrations to be effective and would not be as useful with long-term low concentrations.

- **Payoff/Benefit to the Air Force.** Assuming success, the primary cost savings to the Air Force would be in downscaling the size of the required treatment system, which is the largest cost associated with pump and treat operations. A secondary benefit would be lower pumping costs.

REQUIREMENTS: This project supports SAC SON 04-82. The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The problem of fuel and solvent contaminated groundwater has been well documented in the IRP Information Management System and site investigation reports.

- **User/Sponsor.** The IRP, MAJCOMs, and the civilian environmental engineering community will use this technology.

- **Advocates Supporters.** AF/CEV, AFCEE, and MAJCOM/DEVs are the advocates.

- **Comments.** This project is being coordinated with in-house and AFIT research efforts.

TECHNOLOGY APPROACH:

- **Major Tasks of Effort.** Locate a suitable field site with existing groundwater contamination. Conduct a field investigation using limited portions of the contaminated aquifer. Determine the effectiveness of pulsed pumping versus continuous pumping. Determine the primary contributing factor to the mass transfer limitations.

- **Methodology/Approach Used to Perform Tasks.** The selected site will be characterized hydrogeologically and mass transfer limitation attributes of the site aquifer material will be determined using laboratory studies in conjunction with the field efforts. Portions of the contaminated aquifer will

be isolated physically, using sheet piling, or hydraulically. Pulsed and continuous pumping will be employed in separate, but essentially identical, areas and the results compared. A nonaqueous phase liquid will later be added to assess the impact of pulsed pumping on the dissolution of the nonaqueous phase liquid. Computer modeling will be used to extend the field results to other types of site and pumping conditions. The potential cost savings will be evaluated.

- Deliverable Requirement. The principal deliverable is a detailed evaluation of the utility of pulsed pumping as a tool in groundwater remediation efforts. All experimental designs, results, and data interpretations will be documented in peer-reviewed publications and a final technical report.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success:

Test areas will be constructed in the field.	FY92
Pulsed pumping will be compared with continuous pumping.	FY93
Effectiveness of pulsed pumping on the dissolution of nonaqueous phase source will be determined.	FY94

TECHNOLOGY TRANSITION PLAN: A field demonstration of optimized extraction/injection pumping strategies is planned and will use the results obtained from this study. The peer-reviewed publications and technical report are major vehicles for transition to the field. A preliminary design guidance will be given to design agents. Technical Data Sheets will be given to design agents. Technical Data Sheets will be given to MAJCOMs/bases. Cost data will be given to the Remedial Action Cost Estimating and Requirements System (RACER).

FUNDING ($K):

FY92	FY93	FY94
300	300	300

RESEARCH ACTIVITY: AFCESA/RA, Dr ~~Mr.~~ David Burris, DSN 523-6007.

RESEARCH TITLE: Treatment of Chlorinated Organics with Aboveground Bioreactors

OBJECTIVE: Identify the optimum trichloroethylene (TCE) biological degradation process. The two best biological systems will be identified through laboratory bench-scale experiments. The two systems will then be tested side by side in pilot-scale bioreactors at a field site at Oak Ridge National Laboratory to determine their relative efficiencies under varying operating conditions.

- **General Problem Statement.** Through the Installation Restoration Program (IRP), over 700 groundwater contamination sites have been identified which contain some solvent type chemical. Trichloroethylene has been identified as being the most frequently found solvent at contamination sites. Problems remediating these sites have been documented in IRP site investigation reports from throughout the Air Force.

- **Limitations/Restrictions of Current Technology.** Typically, groundwater contaminated with chlorinated organics is cleaned up by one of two methods: aqueous phase carbon sorption or air stripping. Both methods are effective in removing the contaminants from groundwater; however, they do have their limitations. Aqueous phase carbon sorption is often costly and is not a destructive technique. The contaminants are simply collected and concentrated on the carbon producing a potential hazardous waste solid, (i.e., the activated carbon). Air stripping is an effective treatment alternative, but it transfers the contaminant from the water to the air. In some instances this contaminated air stream is also regulated and requires treatment.

BENEFITS: Development and optimization of this treatment technology will offer a cost-effective destructive method of treating TCE contaminated groundwater.

REQUIREMENTS: This project supports SAC SON 82-04 which documents the need for the development of technologies for remediating contaminated groundwater.

- **Advocates/Supporters.** AFCEE and AF/CEV are strong advocates.

- **Deliverable Requirement.** The principal deliverable is sufficient design, operating, and efficiency data from which to scale-up and design a full-scale bioreactor unit. A recommendation will be made on the best (most efficient) biological system to be used for TCE contamination as well as appropriate reactor configuration for use with that biological system.

- **Comments.** This research will be a jointly funded effort with Oak Ridge National Laboratory (ORNL). It is being coordinated with researchers at the Gulf Breeze EPA Lab and at the University of Tennessee.

TECHNICAL APPROACH:

- **Major Tasks of Effort.** Two bioreactor systems will be tested side by side at a groundwater contamination site (K-25) at the Oak Ridge National Laboratory. The efficiency of the two biological systems will be studied for

biodegrading TCE in the groundwater under varying reactor operating conditions. The impact of inorganic constituents in the groundwater on reactor performance will be studied. The lower limit of treatment using this technology will also be studied and will include ways to enhance this lower limit if it proves to be above desirable levels. A cost comparison will be made between the most effective reactor system and the currently used physical/chemical treatment technologies.

- **Methodology/Approach Used to Perform Tasks.** HQ AFCESA has loaned ORNL two pilot-scale bioreactor units for use in this effort. These were constructed for AFCESA by Battelle Columbus for a previous field effort. Preliminary laboratory testing will be performed to identify any operational problems with the reactors. The reactors will then be transported to the field site and operated for approximately a one-year period. They will be set up side by side in the field, treating the same contaminated groundwater flow, and operated under a wide variety of operating conditions.

- **Description of Tasks Funded by Other Agencies.** ORNL will provide 65% of the total funding for this three-year effort. HQ AFCESA is currently funding in-house researchers to work on the development of a biological reactor system for the degradation of chlorinated aromatic compounds. Information concerning reactor configuration and operation will be shared to enhance these two efforts.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success:

Reconfiguration of pseudomonas reactor	March 1992
Field operation of methanotrophic bioreactor	June 1992
Field operation of pseudomonas bioreactor	June 1993
Field report to include cost data, operational/performance data and recommendations on use of the two biological systems.	September 1993

TECHNOLOGY TRANSITION PLAN: Once the technology is validated, design guidance, and cost data will be distributed to the service agents/contractors and technical data sheets will be submitted to the MAJCOMs. Following a successful demonstration, the operating data, cost information, and scale-up criteria will be transferred to HQ AFCESA/RAV to plan and perform a full-scale demonstration. An estimate of the funding required for this effort will be developed at the conclusion of the present effort.

FUNDING ($K):

FY92	FY93
400	400

RESEARCH ACTIVITY: AFCESA/RA, Ms. Alison Thomas.

RESEARCH TITLE: Pilot-Scale Validation of Liquid Phase Oxidation

OBJECTIVE: Field validate pilot-scale destructive technologies to oxidize organic contaminants in groundwater using liquid-phase catalysis. The operating characteristics and destruction efficiencies will be used in the follow-on project to optimize and design a full-scale liquid phase catalytic reactor.

- **General Problem Statement.** Estimates, based on the Installation Restoration Program Information Management System (IRPIMS), indicate that over half of the Air Force bases have groundwater contaminated with organic compounds above the drinking water limits.

- **Limitations/Restrictions of Current Technology.** Treatment by air stripping is limited to volatile compounds. The stripper will also plug up if the groundwater contains a high iron content. Treatment by activated carbon is too expensive. Both processes generate a residual waste stream that requires further processing.

BENEFITS: This catalytic reactor will enable engineers responsible for IRP groundwater cleanups to destroy organic contaminants in the liquid phase. The products of destruction will be harmless carbon dioxide, water, and minerals of the contaminants. The reactor will cost-effectively treat all organically contaminated groundwater.

REQUIREMENTS: SAC SON 04-82, the Environmental Quality R&D Strategic Plan, and the Remedial Investigations.

- **User/Sponsor.** IRP managers and engineers at each base.

- **Advocates/Supporters.** AF/CEV and AFCEE.

- **Deliverable Requirements.** Preliminary, intermediate, and final designs with estimated costs of project. Operation and maintenance plan, quality assurance project plan, site safety plan, A/E services during construction, design information for full-scale effort, technology summary sheets, and final report.

TECHNICAL APPROACH: Design, construct, and operate a liquid phase catalytic reactor. Compare operational efficiencies of this novel process to other commercial advanced oxidation processes. Produce require documentation.

- **Methodology/Approach Used to Perform Tasks.** Operational testing of the unit will be such that the scale up factors and overall performance of this new technology can be determined. The performance of the novel unit will be compared to commercial oxidation processes tested at the same site under the same conditions. Technologies being tested will destroy the contaminants in the water phase. This includes UV/H202. Ozone, sonication, and various combinations of the process. Parameter testing will determine the range and scope of application of this new technology as it operates in the field.

- Description of Tasks Funded by Other Agencies. A portion of this project will be using sunlight as the energy source. DoD, through the National Renewable Energy Lab (NREL) may provide some funding, although an exact amount has not been agreed upon.

MILESTONES/EXPERIMENTS USED TO DEMONSTRATE SUCCESS:

Design oxidation reactors	August 1992
Select and obtain commercial processes for comparison studies	September 1992
Start field tests	November 1992
Initial technical data sheet completed	March 1993
Preliminary design guidance	June 1993
Long-term field tests completed	April 1994
Final technical data sheet completed	April 1994
Final report/design specifications	September 1994

Funding delays in the contract to develop the new oxidation systems will impact this effort by delaying the availability of the process for testing.

TECHNOLOGY TRANSITION PLAN: A preliminary and final design package will allow this technology to transition directly to the field to be used in feasibility studies by AFCEE and other IRP site restoration agencies. In addition, the results from the pilot-scale work will be published in a technical report and peer-reviewed journal articles. Design, cost, and performance data would be forwarded, via Technical Data sheets and the design packages, to IRP engineers as the MAJCOM and base level.

FUNDING ($K):

FY92	FY93	FY94
300	650	450

RESEARCH ACTIVITY: AFCESA/RA, Captain Ed Marchand, DSN 523-6007.

RESEARCH TITLE: Groundwater Transport in Model Systems

OBJECTIVE: Develop techniques to obtain data on transport of organic chemicals using scaled-down well fields with controllable hydrologic parameters and organic chemical solute inputs. Data from the physical box model will be used to testing existing groundwater contaminant transport computer codes under various initial and boundary conditions.

LIMITATIONS/RESTRICTIONS OF CURRENT TECHNOLOGY: Many existing computer models are purported to predict groundwater transport of organic chemical compounds. These computer codes have not been adequately tested with real data. Furthermore, contaminant source terms for the models are currently poorly understood. Adequate code testing involves model calibration at a particular time and later successful prediction (based on calibration parameters) of the spatial evolution of the solute distribution. The expense and time required to definitively determine model accuracy has resulted in untested models being used as the basis for multimillion dollar decisions.

BENEFITS: Computer codes that have been tested in a model aquifer with varied aquifer neterogeneity and stratification can be applied with more confidence in cases of accidental release of organic compounds and fuels to groundwater. IRP managers and contractors will be better able to apply existing models selecting the optimum analysis and code for a particular release situation. Results of this research will aid decision makers in determining the number and location of wells at groundwater cleanup sites. Use of tested computer codes will minimize costs of spill monitoring and site remediation.

REQUIREMENTS: The Secretary of Defense is required by 10 USC 2702 to carry out a program of research, development, and demonstration with respect to hazardous wastes. The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and field demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The remediation problems have been documented in IRP site investigation reports from throughout the Air Force.

USER/SPONSOR: Generally the scientific and engineering community will use these results to enhance the understanding of hydrophobic organic transport processes. Specifically, the Air Force and their remediation contractors will employ the information gained to more effectively make decisions regarding decontamination.

- **Advocates.** HQ USAF/CEV and AFCEE are the advocates.

- **Comments.** Cornell University, University of Florida, and the College of William and Mary have coordinated on this study.

TECHNICAL APPROACH:

- **Major Tasks of Effort.** The novelty of this approach is that computer codes will be run on data collected under controlled laboratory conditions in model aquifer boxes.

- **Methodology/Approach Used to Perform Tasks.** Laboratory experiments on the aqueous dissolution of liquid mixtures simulating a jet fuel will be conducted to improve our understanding of the contaminant source term. Variations of low, aquifer material heterogeneity, solute, initial and boundary conditions, aquifer material grain size, and hydraulic conductivity are practical in the model aquifer boxes so the codes can be tested. Since batch and column-based sorption coefficients do not generally agree, but differ by a nearly constant factor, comparison with box model coefficients will indicate which value is more appropriate for use in actual groundwater situations. Based on available computer codes and experience during the past year in the design, construction, and use of well field box models, success in this endeavor is probable.

- **Deliverable Requirement.** A final report detailing all experimental findings and recommendations for selection of current transport model use by the Air Force. If no models exist that adequately describe transport, then the best candidate will be modified for use.

- Description of **Tasks Funded** by Other **Agencies:** None.

TECHNOLOGY ASSESSMENT:

- **Milestones/Experiments Used to Demonstrate Success.** The midterm exam is attaining a 95 percent mass recovery for a pulsed injection of retarded tracer in the box model. The final exam will be proof that an existing groundwater model can predict far field contaminant concentrations and transport times with 95 percent confidence.

TECHNOLOGY TRANSITION PLAN: If available models prove to be unsatisfactory at predicting transport, a FY93 follow-on project of $200K will be necessary to modify an existing model. Once specific models have been validated, results and modifications will be provided to the organization responsible for supporting the model. Changes can then be incorporated and model updates distributed to USAF and DoD design and construction agencies and technical data sheets (announcing availability of these prediction tools) to MAJCOMs.

FUNDING ($K):

FY92	FY93
80	100

RESEARCH ACTIVITY: AFCESA/RA, Captain Ed Marchand, DSN 523-6007

RESEARCH TITLE: Biodegradation Technology for Hazardous Waste Treatment

OBJECTIVE: To examine specific aspects of several recently identified biological systems for applicability to the on-going development of biological treatment technologies for the degradation of typical Air Force IRP contaminants.

- **General Problem Statement.** Through the Installation Restoration Program (IRP), over 1,000 JP-4 jet fuel and 700 solvent contamination sites have been identified. Problems remediating these sites have been documented in IRP site investigation reports from throughout the Air Force.

- **Limitations/Restrictions of Current Technology.** Typically, contaminated groundwater is cleaned by one of two methods: aqueous phase carbon sorption or air stripping. Both methods are effective in removing the contaminants from groundwater; however, they do have their limitations. Aqueous phase carbon sorption is often costly and is not a destructive technique. The contaminants are simply collected and concentrated on the carbon producing a potential hazardous waste solid (i.e. the activated carbon). Air stripping is an effective treatment alternative, but it transfers the contaminant from the water to the air. In some instances this contaminated air stream is also regulated and requires treatment. In situ biological treatment technologies are being developed at AFCESA to overcome the limitations of pump-and-treat physical/chemical treatment technologies. Through the development of these in situ technologies, additional research questions have been generated concerning the most effective utilization of these treatment technologies.

BENEFITS: Complete development and optimization of biological treatment technologies for fuel and solvent contamination offer a cost-effective destructive method of treating contaminated groundwater. A more thorough understanding of how these in situ techniques work, will reduce potential operational problems when they are transitioned to the field for full-scale testing and will increase the probability of success.

REQUIREMENTS: This project supports SAC SON 82-04 which documents the need for the development of technologies for remediating contaminated groundwater.

- **User/Sponsor.** This research will provide MAJCOM engineers and their consultants data to prepare and conduct feasibility studies for remedial action plans.

- **Advocates/Supporters.** AFCEE and AF/CEV are strong advocates.

- **Deliverable Requirement.** The principal deliverable will be data and information from bench-scale studies that can be incorporated into ongoing pilot and full-scale in situ biodegradation efforts.

TECHNICAL APPROACH: Two separate questions will be answered pertaining to the in situ biodegradation of JP-4 jet fuel in groundwater. Bench-scale studies will be performed to determine the rate and extent of naturally occurring anaerobic biodegradation by methanogenic and sulfate-reducing organisms. The second question to be answered at the bench scale level is the biodegradation of the jet fuel components when they exist in the nonaqueous phase liquid. The biodegradability of organic compounds present in the nonaqueous phase liquids will be determined as well as factors affecting the biodegradation of

these compounds. Methods of enhancing the biodegradation of pollutants in the nonaqueous phase will also be explored. Contaminated aquifer material from an Air Force JP-4 contamination site will be used in the bench-scale experiments.

- **Methodology/Approach Used to Perform Tasks:** Both flask and column microcosm studies will be used to answer the questions stated above. Methanogenic and sulfate reducing organisms will be isolated from contaminated soil. The extent and rate of benzene, toluene, xylene (BTX) degradation will be monitored using these organisms. Aerobic hydrocarbon degrading organisms will also be isolated from contaminated aquifer material and used in bench-scale experiments to determine the degradability of JP-4 components when they exist in a nonaqueous phase liquid.

- Description of **Tasks Funded by Other Agencies:** The U.S. EPA Robert S. Kerr Environmental Research Laboratory is currently funding research into the anaerobic degradation of jet fuel components. On-going research into the degradation of jet fuel components in nonaqueous phase liquids is currently being supported by the National Science Foundation.

TECHNOLOGY ASSESSMENT:

Milestones/Experiments Used to Demonstrate Success:

Collection of aquifer material	March 1992
Bench-scale experiments complete	June 1993
Final report to include recommendations on how data and information can be incorporated into current in situ biodegradation efforts	September 1993

TECHNOLOGY TRANSITION PLAN: The products of this research are technical reports and professional publications typically for the R&D community and Technical Data Sheets for distribution to the operational field (MAJCOMs and bases). The information and data generated will be incorporated into our ongoing 6.3 and 6.4 in situ bioremediation efforts.

FUNDING ($K):

FY92	FY93
200	200

RESEARCH ACTIVITY: AFCESA/RA, Captain Catherine Vogel, DSN 523-6007

RESEARCH TITLE: Chemical Characterization of Carbonaceous Materials from Aquifers

OBJECTIVE: Develop and evaluate various chemical methods for removing aquifer organic material from its inorganic matrix. Once it is separated, different instrumental techniques will be used to characterize the isolated organic matter.

- **General Problem Statement.** The exact chemical nature of subsurface organic geochemical compounds is unknown and cannot be inferred from surface soil composition. Elucidation of the chemical structure of the organic material attached to aquifers materials is a vital link in the understanding of fate and transport of chemical contaminants.

- **Limitations/Restrictions of Current Technology.** Current transport prediction capabilities are limited by the lack of understanding of the chemical structure of organic matter on aquifer materials. The accuracy of mathematical models depends on the reliability of the parameters (kinetics, organic carbon content, etc.) they require.

BENEFITS: Effective management of groundwater contamination sites depends on our ability to predict contaminant movement in the aquifer. An understanding of the chemical nature of the organic material in the aquifer will enhance our predictive capabilities, thus allowing more accurate cleanup cost estimates and environmental impact assessments.

REQUIREMENTS: The R&D program for the Installation Restoration Program (IRP) seeks to test, evaluate, and field demonstrate more cost-effective technologies for cleanup of hazardous waste sites. The contamination problems have been documented in IRP site investigation reports from throughout the Air Force. This is a proposed project under the mandated IRP R&D program to characterize and understand contaminant impacts on the environment.

- **User/Sponsor.** MAJCOM/DE and their contractors and the scientific and engineering community.

- **Advocates/Supporters.** HQ USAF/CEV and AFCEE are the advocates.

- **Deliverable Requirement.** The principal deliverable will be a report detailing the experimental findings and conclusions. A chemical description of the organic material from the aquifer will give us a better understanding of interactions between Air Force contaminants and aquifer materials.

TECHNICAL APPROACH: Develop new separation techniques to isolate organic substances from aquifer material, then compare these methods with the current methods for surface soil. Use instrumental techniques to characterize the isolated organic material.

- **Methodology/Approach Used to Perform Task.** Aquifer material from several Air Force sites will be extracted using conventional separation methods as well as supercritical fluid extraction techniques. The extracted material will then be analyzed for functional groups by spectroscopic methods

(Raman, solid-state NMR). These results will be compared to analyses of surface soil organic matter as well as correlated with retardation measurements of chemical contaminants in these aquifer materials.

- **Deliverable Requirement.** A final report detailing all of the experimental findings and a recommendation on the extraction technique and spectroscopic method most suitable for the characterization of carbonaceous material.

- **Description of Tasks Funded by Other Agencies.** None.

TECHNOLOGY ASSESSMENT:

- **Milestones/Experiments Used to Demonstrate Success.** The progress of this research effort will be evaluated on the success of the three major elements. The evaluation of the extraction techniques will be accomplished by the end of year one. Analysis of the extracted organic material will be finished in year two, and the development of a data base correlating the spectroscopic data with retardation measurements will be accomplished in the final year of funding.

TECHNOLOGY TRANSITION PLAN: Following completion of this study, the results will be published in technical reports and peer-reviewed scientific journals. An understanding of the chemical nature of the subsurface organic matter gives us more accurate estimation of the sorption coefficient of chemical contaminants in groundwater, which is one of the principal parameters used in groundwater models such as Saturated-Unsaturated Transport (SUTRA) and Method of Characteristics (MOQ). The predictive capabilities of these groundwater models are used to design the cleanup strategies used in the field.

FUNDING ($K):

	FY92	FY93	FY94
AFCESA	150	150	150

RESEARCH ACTIVITY: AFCESA/RA, Mr. Chris Antworth, DSN 523-6007.

RESEARCH TITLE: Advanced Microporous Membranes

OBJECTIVE: To prove that microporous hollow-fiber membrane system can strip oil from groundwater without constant clogging. Also a determination will be made to ensure the membrane process is economically superior over existing groundwater treatment technologies.

APPROACH: The MASX/MADS processing system will be set up to operate in a continuous process rather than a batch mode. The potential of the solvent extraction unit and the distillation strip unit will then be evaluated for superior VOC selectivity and higher capacity over previously evaluated solid sorbent systems. The VOCs to be investigated most probably will be trichloroethylene, tetrachloroethylene, carbon tetrachloride and benzene.

- **Limitations of Current Technology.** Packed-tower aeration is the most common current technology for removing VOCs from water. The VOCs are transferred from the water to the air, and then the VOC-laden air must again be treated to remove and destroy the contaminants. Catalytic oxidation systems, an emission control technology for the packed towers, require high energy consumption in order to achieve the high temperatures necessary to destroy the VOCs in air.

BENEFITS: If energy consumption and decontamination performance can be improved, millions of dollars can be saved throughout the DoD in military site restoration programs. The higher fluxes that are achievable translate to much smaller sizing of equipment and, therefore, lower capital and operating costs.

PARTNERS AND RELATED ACTIVITIES: MAJCOMs, DOE and other federal, state and local government agencies. This research is being accomplished by the University of Chicago under DOE contract at the Argonne National Laboratory. Funding for the development of the Advanced Microporous Membrane technology development effort is being provided by the Air Force and co-funded by DOE.

MILESTONES:

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                                  Fiscal Year
                                  1992        1993        1994
                                  1  2  3  4  1  2  3  4  1  2  3  4
(1) Experimental Procedures        x--------x
(2) Lab-Scale                         x-------------------x
(3) Alternative Evaluation                     x-----x
(4) Groundwater Demonstration                        x-------------x
(5) Full-Scale Design                                   x--------x
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TECHNOLOGY TRANSITION PLAN: Following successful demonstration of the pilot scale MASX/MADS system, the appropriate technical specifications for procurement of equipment, overall system design and operating guidelines, and any other information relevant to field installation at a military facility will be transferred to HQ AFCEE for Air Force wide implementation at the 6.4 level of effort and initiation of the system acquisition process.

FUNDING ($K):

FY92	FY93	FY94
120	100	80

RESEARCH ACTIVITY: HQ AFCESA/RAVW, Paul F. Carpenter, DSN 523-6022.

RESEARCH TITLE: Spill Remediation Guide

OBJECTIVE: To compile treatment technologies and practical research findings into a guide that would help base and MAJCOM engineers determine a course of action in the assessment and remediation of a variety of fuel spill sites.

APPROACH: Review research that has been conducted by the Engineering & Support Agency and other Federal agencies in the areas of monitoring technologies, fate and transport of hydrocarbon contaminants, free product recovery, and soil/groundwater treatment technologies. Compile this information into a format easily usable by base and MAJCOM engineers. This guide will cover fuel properties, fate and transport issues, site investigations, and remediation methods so engineers will be able to assess and remediate fuel contamination sites.

BENEFITS: Base level and MAJCOM engineers do not have the resources to search numerous references to develop strategies for the assessment and remediation of fuel contamination sites. Engineers will be able to use this practical and effective guide to assist them in remediating fuel spill sites.

PARTNERS AND RELATED ACTIVITIES: AFCEE and AF/CEV are strong advocates.

MILESTONES:

Research published technical reports/journal articles	April 1992
Final Report/Guidelines to assess and remediate fuel contaminated sites	April 1993

FUNDING ($K):

FY92
150

RESEARCH ACTIVITY: HQ AFCESA/RAVW, Ms. Alison Thomas, DSN 523-6028.

RESEARCH TITLE: Demonstration of Soil Washing at Beale AFB with EPA (Site Program)

BACKGROUND: The purposes of the cooperation and coordination are: (1) to ensure mutual benefit from the respective RD&D programs, (2) to facilitate cooperative RD&D at mutually agreed upon sites, and (3) to ensure rapid technology transfer between U.S. EPA, and DoD laboratories and facilities. The RD&D includes but is not limited to assessments, monitoring, treatability studies, laboratory and pilot scale research, field studies, and demonstrations.

This agreement is intended to facilitate cooperative efforts for mutual provision of RD&D and technical assistance by both agencies in the conduct of programs affecting the quality of the environment through waste cleanup and waste minimization.

OBJECTIVE: The DoD will co-fund a SITE demonstration and several treatability studies for Air Force wastes under the U.S. EPA's SITE Program. The Demonstration Program is part of the U.S. EPA Superfund Innovative Technology Evaluation Program (SITE). Development of viable alternative technologies for use in Superfund site remediations is the goal of the SITE Program. Technologies are solicited for the SITE Program yearly through Requests and Pre-Proposal. Applications are reviewed by U.S. EPA and those deemed acceptable are invited to submit detailed Cooperative Agreement Applications to U.S. EPA's Grants Administration. These applications are reviewed by two expert technical reviewers outside of U.S. EPA and one in-house staff expert. After receipt of reviewers comments, a meeting of U.S. EPA SITE staff is held, that results in identification of projects that are recommended for funding.

The U.S. EPA and DoD have mutual interest in some of the waste management projects that were selected for demonstration and treatment. The DoD reviews information on the U.S. EPA selected projects to identify those projects that the DoD will participate in. The projects that the DoD will co-fund will be specifically identified by separate letters from the DoD staff level Point of Contact to the U.S. EPA staff level Point of Contact. Information gained from these efforts can be utilized at DoD sites. DoD sites will be evaluated at full scale when they are accepted into the SITE Demonstration Program.

The DoD will provide funding of $587K for FY92. This input provides a cooperative effort between the DoD and U.S. EPA to develop and acquire information from the technologies through ongoing participation.

The U.S. EPA will administer and monitor these Cooperative Agreements according to their internal procedures and will coordinate with and receive input from a DoD counterpart, who will be assigned to follow the progress of the activity. In the management of the project, U.S. EPA personnel will be acting as an agent for the DoD.

The projects will be developed according to the Detailed Work Plans and Quality Assurance Project Plans submitted to and approved by the U.S. EPA. The DoD will be provided with copies of these plans for comment.

MEETINGS: EPA will arrange kick-off meetings with the Technology Developers. DoD representatives will be invited to participate in these meetings.

A minimum of two meetings per year will be held with the Technology Developers at their facility or the U.S. EPA in Cincinnati. DoD representatives will be invited to participate in these meetings.

DELIVERABLES: The following reports received by the U.S. EPA from the Technology Developers will be sent within 7 days, to the assigned DoD representative by the U.S. EPA Project Manager:

- Quarterly Progress Reports
- Technical Systems Audit Report
- Interim Reports for 2 year projects
- Papers submitted for EPA Research Symposia
- Final Report and Project Summary

FUNDING ($K):

FY92

587

RESEARCH ACTIVITY: HQ AFCESA/RAVW, DSN 523-6022

Alison Thomas

RESEARCH TITLE: Emerging Technologies with EPA Support of Site Program

BACKGROUND: The purposes of the cooperation and coordination are: (1) to ensure mutual benefit from the respective RD&D programs, (2) to facilitate cooperative RD&D at mutually acceptable sites, and (3) to ensure rapid technology transfer between U.S. EPA, and DoD laboratories and facilities. The RD&D includes but is not limited to assessments, monitoring, treatability studies, laboratory and pilot scale research, field studies, and demonstrations.

This agreement is intended to facilitate cooperative efforts for mutual provision of RD&D and technical assistance by both agencies in the conduct of programs affecting the quality of the environment through waste cleanup and waste minimization.

OBJECTIVE: The DOA will co-fund several waste management and minimization projects under the U.S. EPA Emerging Technologies (ET) Program. The ET Program is part of the U.S. EPA Superfund Innovative Technology Evaluation (SITE) Program. The ET Program provides a framework to encourage the bench- and pilot-scale testing and evaluating of technologies that have been conceptually. Development of viable alternative technologies for use in Superfund site remediations is the goal of the ET Program.

DELIVERABLES: The following reports received by the U.S. EPA from the Emerging Technology Developers will be sent within 7 days to the assigned DoD representative by the U.S. EPA Project Manager:

- Quarterly progress reports
- Technical systems audit report
- Interim reports
- Papers submitted for EPA research symposia
- Final report and project summary

FUNDING ($K):

FY92

600

RESEARCH ACTIVITY: HQ AFCESA/RAVW, DSN 523-6022

Same

RESEARCH TITLE: Bioventing Demonstration with EPA

OBJECTIVE: The U.S. EPA Bioremediation Field Initiative is a joint program of EPA's Office of Research and Development and Office of Solid Waste and Emergency Response designed to assist agencies and organizations charged with hazardous waste site cleanup in conducting bioremediation treatability studies and field tests/evaluations. The guiding criterion in site selection is assisting cleanup efforts where bioremediation is already underway or planned in the near future. The major objective of the initiative is to provide "added value to the planned or ongoing study, but not to interfere with or take over evaluations that are being performed by the Principal Responsible Party (PRP) and its contractors.

APPROACH: The project will be enhanced by conducting additional field work and analysis that would not otherwise be done. The initiative will not impede the timeliness to which the PRP is committed in satisfying progress milestones mandated by the cognizant EPA Regional Office. U.S. Air Force installations over the years have accumulated numerous hazardous waste sites requiring remediation. One major class of installations that have substantial remediation needs are Air Force bases. A primary source of soil contamination at these bases is JP-4 jet fuel spills. Two bases where JP-4 spill cleanup is underway are Eielson Air Force Base (AFB) near Fairbanks, Alaska, and Hill AFB near Salt Lake City, Utah.

The hydrocarbon composition of JP-4 jet fuel spills have been shown to be readily amenable to bioremediation. One form of bioremediation that appears to be particularly well suited to in-situ degradation of vadose (unsaturated) zone hydrocarbon contamination is bioventing. Bioventing is the process of injecting air into contaminated soil at low rates that will stimulate enhanced indigenous microbial activity and pollutant breakdown but will not result in significant extraction or stripping of contaminated vapors to the atmosphere.

DELIVERABLES: Annual progress reports will be submitted for both sites by Battelle to EPA and the Air Force presenting data and conclusions for the previous year's operation. Final reports will be submitted for both sites within 4 months following completion of field data collection. The final reports will document all project findings and provide assessments of process and cost effectiveness. Although the progress and final reports delivered to satisfy Battelle contract with EPA will necessarily emphasize the EPA-component portions of the projects, results generated under the Air Force components will also be incorporated, as appropriate, for comparative purposes.

FUNDING ($K):

The costs of the two studies are broken down by year below:

	FY92
• Eielson AFB Study ($K)	100
• Hill AFB Study ($K)	75
• Total ($K)	175

RESEARCH ACTIVITY: HQ AFCESA/RAVW, DSN 523-6022

SAME

RESEARCH TITLE: Metabolic Pathway Control

OBJECTIVE: Discover the mechanisms that control metabolic pathways used for biodegradation of hazardous wastes.

APPROACH: Recent successes with in situ biological treatment of hydrocarbons fuels suggest that such techniques can be applied to synthetic organic chemicals. Microorganisms with the ability to degrade the specific contaminants have been isolated and their biodegradation kinetics and pathways have been determined. Understanding of the regulation will be gained by isolation and sequencing of the genes involved in the pathways. When the basic control mechanisms are understood, regulation by mixed substrates under environmental conditions will be examined. Results will be used for construction of constitutive strains which will allow design of treatment systems for mixed wastes in the absence of natural inducers.

BENEFITS: Research results will be used to design in situ or on-site biological treatment. Biological techniques will be less expensive than excavation or other mechanical techniques. They provide the best alternative for removal of residual levels of contaminants and can be conducted with minimal disruption of the primary mission of the base.

PARTNERS AND RELATED ACTIVITIES: This research will be conducted in-house and correlates with project JON 19007070, "Biodegradation of Mixed Chlorinated Solvents" and project JON 1900W92L, "Biodegradation Technology for Hazardous Waste Treatment".

MILESTONES:

Discovery of regulatory mechanisms that determine whether genes are under positive or negative control.	FY92
Construction of mutants that allow multiple contaminants.	FY93

FUNDING ($K):

FY92	FY93	TOTAL
210	293	503

RESEARCH ACTIVITY: AFCESA/RAV, Dr. Spain, DSN 523-6058.

RESEARCH TITLE: Anaerobic Biological Treatment for Remediation of Sites Contaminated by C_1 and C_2 Chlorinated Hydrocarbons

OBJECTIVE: Develop a novel bench-scale bioreactor system that will use anaerobic microorganisms to degrade chlorinated C_1 and C_2 compounds under controlled conditions. This is the second phase of a two-phase research project. The first phase demonstrated the ability of the anaerobic microorganisms to degrade chlorinated C_1 and C_2.

APPROACH: The successful operation of bench-scale anaerobic bioreactor for the biodegradation of highly chlorinated solvents. Bottle assays to determine required co-metabolites and operating conditions of the reactor. Design, fabrication and operation of bench-scale reactor system to degrade aqueous stream of tetrachloroethylene.

BENEFITS: The technology will provide the Air Force with an efficient and relatively inexpensive method for removal of chlorinated hydrocarbons from groundwater.

PATTERNS IN RELATED TECHNOLOGY: HQ USAF/CEV, MAJCOM's and AFCEE are expected to be advocates of this effort. HQ USAF/CE, MAJCOM's, base level engineers, and IRP contractors will use this technology. Dr. Jim Gossett, Cornell University is conducting this phase of research under a BAA contract.

MILESTONES:

FY92:

- Completion of bottle assay experiments to determine types and concentrations of required co-metabolites.

- Design, fabrication, and operation of bench-scale reactor system.

- Successful degradation of tetrachloroethylene at a range of concentrations (1 ppm to 50 ppm) to ethylene (overcoming the transition to the more toxic vinyl chloride).

FUNDING ($K):

	FY92	TOTAL
AFCESA	50	50

RESEARCH ACTIVITY: AFCESA/RAVW, Captain Catherine Vogel, DSN 523-6036.

RESEARCH TITLE: Catalytic Destruction of Chlorinated Organics

OBJECTIVE: Develop and test catalysts and catalyst supports for the destruction of chlorinated organics from air stripping emissions.

APPROACH: Preliminary results (destruction efficiency versus temperature) from another Air Force/EPA effort have identified a catalytic system (catalyst and support) containing a transition metal oxide capable of destroying trichloroethylene (TCE) at temperature of 900°F. More important has been the development of an understanding of the TCE oxidation process. This information has led to the development of other transition metal oxide systems. The catalysts contain chemicals that will be environmentally acceptable. Using the information from the preliminary tests, the systems will now be optimized for Air Force needs. Testing will determine the effect of water vapor, temperature, catalyst support, and mixtures on destruction efficiency, selectivity, and catalyst life. This information will be used to determine scale-up and estimate economic characteristics.

BENEFITS: With a better understanding of the fundamentals of catalysis, improved catalytic units can be designed and constructed. These would be more efficient and less expensive to operate. The use of catalytic devices on air strippers could vastly expand the use of air-stripping technology to contaminated aquifers. In some states, air stripper use is now prohibited because of potentially hazardous air emissions. Also, the catalytic units could be added to existing air-stripping systems, currently not using emissions control, when the need arises (i.e. changes in regulatory requirements).

PARTNERS IN RELATED PROGRAMS: "The Deactivation of Oxidation Catalysts Used to Control Air-Stripping Emissions," JON 19002101, and "Air Stripping with Emissions Control," JON 37883063, are related to this project. Both are further efforts to establish catalytic oxidation as a viable technology for destroying VOC emissions in air. AF/CEV and HSD/YAQ are advocates. This project is a cooperative effort with the U.S. Environmental Protection Agency Air and Energy Engineering Research Lab (EPA AEERL). The performing agency is the University of Akron; Dr. Howard Greene is the principal investigator.

MILESTONES:

FY92: Developed catalytic systems to destroy TCE. Prove greater than 95% destruction of TCE at less than 900 degrees F.

FUNDING ($K):

	FY92
AFCESA	90

RESEARCH ACTIVITY: AFCESA/RAV, Captain Edward G. Marchand, DSN 523-6023.

RESEARCH TITLE: Fiber Optic Monitoring System Development

OBJECTIVE: This project will develop fieldable prototypes of fiber optic monitoring systems from laboratory breadboard systems developed through previous Air Force projects. Fiber optic monitoring will allow in situ, real-time analysis.

APPROACH: Three related but independent research and development efforts will be undertaken: Transportable Laser Spectrometer (TLS), Attenuated Total Reflection (ATR) Fiber Optic Sensor, and Fiber Optic Electrochemilumenescence (ECL) Sensor. Spectroscopic analysis has been well established within the laboratory and there have been several technological advances recently. This project provides for further development of the technology of transmitting light through optical fibers to a monitoring location and returning the resulting light. The TLS effort has two objectives; the first is to is to simplify the system for monitoring a specific contamination, e.g., benzene; the second is to provide a versatile site investigation/monitoring system that could be used for qualitative and quantitative analysis of contaminants. The ATR Fiber Optic Sensor effort will be useful for monitoring both vapor and aqueous phase contaminants. This sensor could be supported by the TLS and will be useful for monitoring complex mixtures of contaminants. The Fiber Optic ECL Sensor does not require stimulation by an external light source but still requires a spectrometer. It has the potential for being an inexpensive sensor for long-term site monitoring.

BENEFITS: Stringent groundwater monitoring requirements using traditional monitoring methods will place a tremendous burden upon Air Force resources because of costs and manning requirements. Air Force personnel will have new options and capabilities available for site investigations and monitoring. Significant cost savings will occur using fiber optic monitoring systems because of smaller, more easily installed monitoring points, reduced operation and maintenance costs, and decreased manning and technical expertise required. The knowledge furnished by improved characterization or monitoring of sites will afford better planned and conducted remedial activities.

PARTNERS IN RELATED ACTIVITIES: Research programs will be carried out at North Dakota State University, the University of Alabama in Huntsville, and by Cape Cod Research.

MILESTONES:

FY92: Base sensor and support system for intensive laboratory testing.
FY93: Small-scale field demonstrations.

FUNDING ($K):

	FY92	FY93
AFCESA	190	600

RESEARCH ACTIVITY: AFCESA/RAVW, Bruce Nielsen, DSN 523-6011.

RESEARCH TITLE: System Integration of Monitoring Technologies - Sensor Data Acquisition, Reduction, Display and Process Control

OBJECTIVE: Integrate monitoring technologies with various data transmission, acquisition, reduction, display, and report generating methods to form a complete monitoring system for a site or installation.

APPROACH: The potential for real time, in situ monitoring is becoming available with the developments that are being made in chemical sensor technologies. Technology exists or is emerging for in situ, real-time monitoring without the labor of collecting and handling of samples. Remote monitoring data may be transmitted via telemetry, conventional, or dedicated communications lines. Areas such as remedial action sites, hazardous waste storage areas, underground storage tanks and pipelines, industrial wastewater point sources, treated wastewater discharge points, air pollution sources, and water supply systems are potential monitoring locations. Current systems that receive input from sensors typically indicate only that an alarm condition exists and not what alternative actions may be taken to correct the condition. A system that allows input from different environmental monitoring systems and provides enhanced output is required.

BENEFITS: The knowledge furnished by improved characterization or monitoring of sites will afford better planned and conducted remedial activities. Significant personnel and time savings, up to 25 percent, will result from an integrated environmental monitoring system. An Air Force installation has the potential for hundreds of monitoring locations.

PARTNERS IN RELATED ACTIVITIES: The Environmental Protection Agency and Department of Energy will support development of a system that will significantly reduce monitoring costs.

MILESTONES: Sensor network support system will be developed by end of FY92. Full-scale demonstrations will occur over FY93-95. It is expected that by the end of FY95 the system will obtain EPA acceptance for satisfying monitoring requirements at a hazardous waste site.

FUNDING ($K):

	FY92	FY93	FY94	FY95
AFCESA	250	500	600	1,100

RESEARCH ACTIVITY: AFCESA/RAVW, Bruce Nielsen, DSN 523-6011.

RESEARCH TITLE: Improved Methods for Monitoring Fuel Biodegradation

OBJECTIVE: Advanced development and evaluation of techniques for the detection, quantification, and determination of remediation rates at Air Force sites contaminated by hydrocarbons. Emphasis will be on the determination of rates of natural and enhanced biodegradation and use of soil gas monitoring. Determining the rates of remediation is critical to the measuring of the success of the remediation and as input into risk analysis models to prove there is little hazard to the environment if the hydrocarbon contaminant is allowed to naturally degrade in place.

APPROACH: To date, there has not been a concerted effort to develop methods for remediation monitoring. This research will develop new protocols for using in situ monitoring devices or sampling and analysis techniques for determining contaminant concentrations and proving when remediation is occurring. It will couple technologies such as fiber optics and solid state electronics with data analysis techniques to give real-time monitoring capabilities. These procedures will assist base-level engineers in monitoring sites containing hydrocarbon contamination.

BENEFITS: The Air Force's potential hazardous waste sites, many of which have hydrocarbon contamination, will require remediation or monitoring. Significant time and cost savings for site investigations will result from improved monitoring techniques. Soil vapor monitoring techniques will eliminate the need for many monitoring will and aid in selecting appropriate locations for further monitoring. Soil vapor collection devices may provide an inexpensive alternative for monitoring hazardous waste sites that have been well characterized. In situ treatment if potentially less expensive and is preferred over conventional treatment methods. Using this monitoring protocol, field engineers will be able to measure the success of active remediation. Natural remediation can also be determined when active cleanup is not warranted. Air Force IRP managers and contractors will use this information to operate treatment systems more effectively.

PARTNERS IN RELATED PROJECTS: "Low-Cost, Long-Term Groundwater Monitoring Devices," JON 19007047, which is directed toward development of CO_2 soil vapor survey techniques and "Floating Fuel Recovery with Residual Cleanup," JON 21037039, is a field biodegradation project that identified the problem this project will resolve. HQ USAF/CEV and AFCEE are advocates.

MILESTONES: FY92 - develop correlations between remediation indicators and rates of remediation.

FUNDING ($K):

	FY92
AFCESA	400

RESEARCH ACTIVITY: AFCESA/RAV, Mr. Bruce J. Nielsen, DSN 523-6011.

AT

RESEARCH TITLE: Biodegradation of Energetic Materials

OBJECTIVE: Identify and develop biological mechanisms, capable of degrading nitroaromatic compounds found in energetic materials, solvents, and plasticizers. The system that proves to be the most efficient will be examined for applicability to the degradation of Air Force IRP wastes and disposal of energetic materials.

APPROACH:

- Major Tasks of Effort. Complete biodegradation of polynitroaromatic compounds has been believed to be impossible. Scientists at AFCESA have recently discovered enzymes that catalyze the removal of the nitro group from aromatic rings. Researchers will determine the regulation, specificity, and kinetics of the enzymes to allow assessment of their relative merits for application to Air Force environmental problems.

- Methodology/Approach Used to Perform Tasks. Recent advances in biotechnology and enzymology will be exploited to extend enzymatic substrate range, allow protein engineering, and construct metabolic pathways. The most promising process will be evaluated for the treatment of soil contaminated with polynitroaromatic compounds and for disposal of energetic materials.

BENEFITS: A more cost effective disposal/remedial alternative will be available for many Air Force contamination sites. Additionally, it will provide an improved understanding of the behavior and eventual fate of nitroaromatic materials that have been released into the environment.

PARTNERS IN RELATED PROJECTS: HQ USAF/CEV, AFCEE, HQ TAC/DE, and MAJCOMS are the advocates. Project being performed in collaboration with Professor H.J. Knackmuss at the University of Stuttgart.

MILESTONES: An early milestone is the development of a biological system that will completely mineralize specific polynitroaromatic compounds such as dinitrotoluenes. Success is demonstrated if the rates and kinetics can be optimized to degrade actual mixed Air Force environmental contamination. The system must not be sensitive to inhibition by low levels of contaminations, such as heavy metals or chlorinated solvents, which are commonly found in waste streams.

FUNDING ($K):

	FY92	FY93	FY94
AFCESA	130	160	160

RESEARCH ACTIVITY: AFCESA/RAV, Robert LaPoe, DSN 523-6035.

V AT

RESEARCH TITLE: Enhanced In Situ Biodegradation Through Soil Venting

OBJECTIVE: Demonstrate the capabilities of bioventing, an in situ biological treatment process, in cleaning up hydrocarbon contaminated soils found in a variety of hydrogeologic conditions. This process has been proven in cleaning up fuel contamination in shallow, sandy, permeable, unsaturated soil.

APPROACH:

- **Major Tasks of Effort.** Choose a field site; design, construct and operate a bioventing system based on optimization data obtained from bench-scale studies.

- **Methodology/Approach Used to Perform Tasks.** Evaluate potential sites for bioventing applicability. Select site based on contaminant concentration and type, hydrogeologic factors and regulatory atmosphere. Perform bench-scale research to define optimum operating parameters. Design, construct, and operate bioventing system for at least two years. Perform final sampling to determine cleanup efficiency of the bioventing technology.

BENEFITS: The technology provides a cost-effective destructive treatment method for many Air Force hydrocarbon soil contamination sites and reduces the associated liability.

PARTNERS IN RELATED PROJECTS: HQ USAF/CEV, the MAJCOM's, and AFCEE are expected to be advocates of this effort. This research is being coordinated with AFCEE. This project is being performed by Dr. Rob Hinchee of Battelle Laboratories, Columbus, Ohio.

MILESTONES:

Field screening tests showing bioventing to be applicable to the chosen site.	FY92
Through process optimization, reducing to the extent possible, the amount of contaminants in the vented air stream.	FY93
Proven reduction in groundwater contaminants through the use of innovative UVB wells as air injection wells.	FY93

FUNDING ($K):

	FY92	FY93	TOTAL
AFCESA	450	400	850

RESEARCH ACTIVITY: AFCESA/RAV, Captain Catherine Vogel, DSN 523-6036.

RESEARCH TITLE: Packed Tower Air Stripping

OBJECTIVE: Evaluate the impact of various parameters (such as iron clogging) on the air stripping process and develop ways to maintain optimum operating conditions in the field. Establish a data base of factors that influence the design and continued cost-effective operation of air stripping towers.

APPROACH:

- Major Tasks of Effort. The overall effort consists of two phases: Phase I is literature review, site selection, site characterization, system design, test plan, and permit acquisition; Phase II equipment purchase or rental, system construction and installation, system operation, sampling, system maintenance, field demonstration, and development of related design manuals and technical documentation. Tests at the Eglin AFB air stripping tower will be conducted to study the causes of clogging and performance degradation effects on both conventional countercurrent and rotary stripping units. Innovative water pretreatment steps will be evaluated on the Eglin unit. The contaminated air effluent stream from the air strippers will be passed through experimental catalytic oxidation beds, developed in other HQ AFCESA/RAVW efforts. New packing materials will also be evaluated on their mass transfer rates, pressure drops for various packing materials, and selection criteria to address various chemically contaminated groundwater remediation problems.

- Methodology/Approach Used to Perform Tasks. This project brings together several initiatives to improve air stripping for the removal of contaminants from ground water. The laboratory studies in reduced clogging, increased mass transfer from packing materials, and new catalyst formulations will be tested in pilot-scale air stripping units at Eglin AFB. These units are known to be limited by high iron concentrations in the groundwater and is an excellent test device.

BENEFITS: Cleaning of clogged packing material is labor intensive. A process to alleviate the clogging problem would reduce the operations and maintenance costs by an average of 15 percent. In addition, new and advanced packing materials would increase the mass transfer rate and offer cost savings in maintenance and energy consumption.

PARTNERS IN RELATED PROJECTS: Catalysts and catalyst supports will be developed by the University of Akron under a separate project for pilot scale test evaluation of chlorine and sulfur resistance. MAJCOM and base-level engineers and their contractors who implement the groundwater treatment designs are the users. The sponsor is HQ USAF/CEV.

MILESTONES:

Field validation of anti-clogging processes	FY93
Testing of new packing materials completed	FY94
Catalytic oxidation tests completed and data base development	FY95

FUNDING ($K):

	FY92	FY93	FY94	FY95	TOTAL
AFCESA	150	250	300	330	1,030

RESEARCH ACTIVITY: AFCESA/RAV, Mr. Paul Carpenter, DSN 523-6022.

AT

In Situ Biodegradation of Jet Fuels

RESEARCH TITLE: Biodegradation Technology For Hazardous Waste Treatment

OBJECTIVE: To examine specific aspects of several recently identified biological systems for applicability to the ongoing development of biological treatment technologies for the degradation of typical Air Force IRP contaminants.

- General Problem Statement. Through the Installation Restoration Program (IRP), over 1,000 JP-4 jet fuel and 700 solvent contamination sites have been identified. Problems remediating these sites have been documented in IRP site investigation reports throughout the Air Force.

- Limitation/Restrictions of Current Technology. Typically, contaminated groundwater is cleaned by one of two methods: aqueous phase carbon sorption or air stripping. Both methods are effective in removing the contaminants from groundwater; however, they do have their limitations. Aqueous phase carbon sorption is often costly and is not a destructive technique. The contaminants are simply collected and concentrated on the carbon producing a potential hazardous waste solid (i.e. the activated carbon). Air stripping is an effective treatment alternative, but it transfers the contaminant from the water to the air. In some instances this contaminated air stream is also regulated and requires treatment. In situ biological treatment technologies are being developed at AFCESA to overcome the limitations of pump-and-treat physical/chemical treatment technologies. Through the development of these in situ technologies, additional research questions have been generated concerning the most effective utilization of these treatment technologies.

BENEFITS: Complete development and optimization of in situ biological treatment technologies for fuel and solvent contamination will offer a cost-effective destructive method of treating contaminated groundwater. A more thorough understanding of how these in situ techniques work will reduce potential operational problems when they are transitioned to the field for full-scale testing and increase the probability of success.

REQUIREMENTS:

- Documented needs. This project supports SAC SON 82-04 which documents the need for the development of technologies for remediating contaminated groundwater.

- User/sponsor. This research will provide MAJCOM engineers and their consultants data to prepare and conduct feasibility studies for remedial action plans.

- Advocates/supporters. AFCEE and AF/CEV are strong advocates.

- Deliverable requirement. The principal deliverable will be data and information from bench-scale studies that can be incorporated into on-going pilot and full-scale in situ biodegradation efforts.

TECHNICAL APPROACH:

Two separate questions will be answered pertaining to the in situ biodegradation of JP-4 jet fuel in groundwater. Bench-scale studies will be performed to determine the rate and extent of naturally occurring anaerobic biodegradation by methanogenic and sulfate-reducing organisms. The second question to be answered at the bench scale level is the biodegradation of the jet fuel components when they exist in the nonaqueous phase liquid. The biodegradability of organic compounds present in the nonaqueous phase liquids will be determined as well as factors affecting the biodegradation of these compounds. Methods of enhancing the biodegradation of pollutants in the nonaqueous phase will also be explored. Contaminated aquifer material from an Air Force JP-4 contamination site will be used in the bench-scale experiments.

Both flask and column microcasm studies will be used to answer the questions stated above. Methanogenic and sulfate-reducing organisms will be isolated from contaminated soil. The extent and rate of benzene, toluene, xylene (BTX) degradation will be monitored using these organisms. Aerobic hydrocarbon degrading organisms will also be isolated from contaminated aquifer material and used in bench-scale experiments to determine the degradability of JP-4 components when they exist in a nonaqueous phase liquid.

The US EPA Robert S. Kerr Environmental Research Laboratory is currently funding research into the anaerobic degradation of jet fuel components. Ongoing research into the degradation of jet fuel components in nonaqueous phase liquids is currently being supported by the National Science Foundation.

MILESTONES:

Collection of aquifer material.	Sep 92
Bench-scale experiments complete.	Jul '93
Final report to include recommendations on how data and information can be incorporated into current in situ biodegradation efforts.	Sep 93

TECHNOLOGY TRANSITION PLAN: The products of this research are technical reports and professional publications typically for the R&D community and Technical Data Sheets for distribution to the operational field (MAJCOM's and bases). The information and data generated will be incorporated into our ongoing 6.3 and 6.4 in situ bioremediation efforts.

FUNDING ($K): This technology is a three-year R&D endeavor with a total of $700K of funding as follows:

	FY92	FY93	FY94
AFCESA	200	300	200

RESEARCH ACTIVITY: AFCESA/RAV, Dr. Jim Spain, DSN 523-6008.

AT

RESEARCH TITLE: Electrolytic Reduction of Chlorinated Hydrocarbon Compounds

OBJECTIVE: To remove groundwater contaminants using electrochemical reduction of chlorinated hydrocarbons such as trichloroethylene (TCE), trichloroethane (TCA), tetrachloroethylene (PCE), and dibromodichloropropane (DBCP).

APPROACH:

- Major Tasks of Effort. There are three major tasks in this Phase I initial effort as follows:

(1) To identify cathode materials, voltages, and medium conditions that will permit control over the product distribution from an electrolysis cell,

(2) To develop techniques that will permit better understanding of the underlying mechanisms that give rise to the observed product distributions in order to achieve a more economic and operational design of actual treatment systems, and

(3) To develop a mathematical model as a framework for design and further conceptual advances.

BENEFITS: This technology will integrate into ongoing development of new and advanced bioremediation projects and could be utilized as a pretreatment for a subsequent biological process. This process could be used to dechlorinate the contaminants to an intermediate which is more easily biodegradable. Large fuel and other energy penalties could be eliminated for incinerating chlorinated hydrocarbons, operating stripping towers, and desorbing the chlorinated hydrocarbons prior to incineration.

PARTNERS IN RELATED PROJECTS: HSD/YAQ and AF/CEV are advocates. The U.S. EPA Robert S.Kerr Environmental Research Laboratory is a very strong supporter.

MILESTONES:

Lab studies of pH, cathode materials, and applied	FY92
potential on 4 to 7 chlorinated hydrocarbons	FY92
Technical progress reports	FY92
Evaluate one major cathode material for 4-7 compounds, or (Alternative)	FY93
Decrease the range of chlorinated hydrocarbons from 4-7 to 1-3 and focus on cathode material and pH	FY93
Final technical report, evaluation & recommendations on optimum operational & design parameters	FY93

FUNDING ($K): The research is for a two-year period at a total funding level of $100K. The yearly allocations are as follows:

	FY92	FY93
AFESC	50	50

RESEARCH ACTIVITY: AFCESA/RAV, Paul F. Carpenter, DSN 523-6022.

AT

ENERGY		
Technology Projects	**Pg.**	Funds $(000)
DOE CLEAN ENERGY/CONSERVATION THRUST AREA	214	
Photovoltaics for Military Applications (DOE)	215	4,000
Windfarm for Military Applications (DOE)	217	1,500
Advanced Technology Assessment and Demonstration of Energy Efficient & Renewable Energy Technologies in DoD Facilities (DOE)	219	2,300
Solar Detoxification of DoD Explosives in Soils (DOE)	221	1,000
ENERGY TOTAL		**$8,800**

DETAILED RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: DOE Clean Energy/Conservation

BACKGROUND:

The Clean Energy/Conservation thrust area proposal has several major, coordinated approaches to providing the Department of Defense (DoD) with solutions to its energy and environmental needs. The approaches provide reliable, cost effective, and environmentally benign sources of energy as well as approaches that provide energy conservation technologies.

These efforts reflect Presidential directives (the Federal Energy Management Executive Order) and Congressional intent (as indicated in SERDP funding priorities).

The Department of Energy (DOE) Clean Energy/Conservation proposal totals only $10.5 million and is specifically geared to DoD requirements. Equipment that will be demonstrated reaches 95-100% reliability rates and is estimated to save DoD over $200 million per year.

The proposal will consist of phases of evaluation, design, and demonstration projects to be completed in FY 1992.

Photovoltaics for Military Applications	$4.0 million
Windfarm for Military Installations	1.5
Advanced Tech. and Energy Efficiency	2.3
Solar Detox of Soils	1.0
	$8.8 million

RESEARCH ACTIVITY: Anthony Bennett, Special Assistant, Conservation and Renewable Energy, U.S. Department of Energy, 1000 Independence Avenue, S.W., CE-13, Washington, DC 20585; (202) 586-8110; FTS 896-8110; Fax (202) 586-8134.

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DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Photovoltaics for Military Applications

OBJECTIVE:

Facilitate the implementation of proven photovoltaic (PV) technologies for cost-effective military applications. The project will address two levels of PV power system utilization: a) small, "packaged" systems that are readily procured and integrated to serve a large number of field activities, and b) medium to large-scale systems designed for a specific site and load. Greater utilization of PV technologies in the DoD will directly support SERDP's objectives of facilitating DoD compliance with existing and anticipated environmental restrictions (The DoD has already begun to encounter air quality compliance problems in some states.).

APPROACH:

The DOE approach is to enhance our ongoing collaborative effort with the DoD PV Review Committee to facilitate greater utilization of PV technologies in the DoD to meet the Congressional requirement of 100 MW of installed PV capacity by 1996. The Committee's activities will require significant amounts of analytical support. In the case of small systems, DOE will help undertake a logistics systems conditioning effort required to put "packaged" PV systems within easy reach of DoD procurement officers - a major obstacle to technology transfer to date. Specifically, we propose to implement two projects to demonstrate the viability of PV for select applications. After first conducting a feasibility study to determine the preferred applications and geographical locations for the applications, required system design, procurement, installation and performance monitoring activities will be undertaken. The "packaged" system would be selected on the basis of its critical need to the military, and the fact that its successful performance could lead to the purchase of numerous additional systems. The medium scale system would be a 100kW hybrid PV/diesel system to be installed at a military installation.

BENEFITS:

Benefits include enhanced environmental compliance, enhanced energy cost-savings and enhanced energy security. Today's PV systems have proven to be highly reliable. Select applications can also be implemented at competitive costs over their total life cycles. PV's zero emissions, low O&M costs, and domestic production are attributes which enable all these benefits to be realized. In addition, greater utilization of PV systems will enhance economies of scale on the production side, promoting further cost reductions -- which will in turn expand the scope of greater PV utilization both in the military and civilian sectors (a SERDP objective).

PARTNERS AND RELATED ACTIVITIES:

The principal partners involved in this effort are the DoD (specifically OSD and the PV Review Committee including the Office of Naval Research, the

Air Force/Engineering and Services Center and Army Corps of Engineers Research Laboratory); the DOE (specifically the Office of Solar Energy Conversion and DOE labs such as Sandia, NREL, Oak Ridge and Lawrence Livermore Laboratories); and industry (SEIA). DOE/DoD collaboration in this area is already underway, together with a number of related outreach activities.

MILESTONES:

This project will be completed by the end of FY92.

FUNDING ($M):

	FY92
SERDP	4.0

RESEARCH ACTIVITY: James E. Rannels, Director, Photovoltaic Technology Division, 1000 Independence Avenue, Washington, D.C. 20585, (202) 586-1720 [Commercial], 896-1721 [FTS], (202) 586-8134 [Fax].

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Windfarm for Military Installations

OBJECTIVE:

The primary objective of this project is to demonstrate the cost and operational benefits of powering small grid and non-grid connected U.S. military facilities in high wind areas with high reliability wind turbines.

APPROACH:

Commercial wind turbines (windfarms of 100 kW or greater) will be purchased, adapted for military application at a selected location with a high wind resource, installed, and operated. In addition, DoD personnel will receive O&M training and participate in the development of test plans for the installation. The project will be managed by the National Renewable Energy Laboratory (NREL) with wind resource assessment and siting support from the Pacific Northwest Laboratory (PNL). NREL and PNL will work closely with the engineering staff of the selected DoD facility to develop procurement plans based on the facility's needs. Testing will be conducted for a period of at least one year.

BENEFITS:

The primary benefit to the DoD facilities will be the reduced consumption of nonrenewable fossil fuels for electrical power generation. At remote installations, wind energy will provide significant cost savings by reducing the amount of diesel fuel that must be transported to the site, as well as providing a renewable source of power at a projected cost of energy of $0.10 - .14/kWh. In addition to cost savings, high reliability wind turbines will reduce requirements for servicing. Larger scale windfarms will have the potential to save 100s of $M in reduced fuel and logistic costs over the lifetime of the wind turbines. Several manufacturers of small, high reliability wind systems are now reporting 95% - 100% availability with little to no maintenance over three- to five-year periods.

PARTNERS AND RELATED ACTIVITIES:

Similar work has been proposed for utility service areas in the Federal Wind Program and should be mutually beneficial. Partners in this work will include the wind energy industry, DoD (U.S. Army CERL), and other Government agencies.

MILESTONES:

This project will be completed by the end of FY92.

FUNDING ($M):

	FY92
SERDP	1.5

RESEARCH ACTIVITY: Peter R. Goldman, Program Manager, Wind/Hydro/Ocean Division, (202) 586-1995

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Advanced Technology Assessment and Demonstration of Energy Efficient and Renewable Energy Technologies in DoD Facilities

OBJECTIVE:

This effort will evaluate the potential input of incorporating advanced energy efficient technologies to DoD housing and demonstrate the efficiency and cost-effectiveness of specific energy conservation and renewable technologies in facilities owned and operated by DoD. Selected technologies include: (a) low E windows, (b) solid-state ballasts, (c) energy-efficient refrigeration systems, (d) heat pump water heaters, (e) passive solar technologies, (f) active solar water heating systems, and (g) geothermal heat pumps for DoD installations.

APPROACH:

A technology impact assessment will be conducted. A planning and demonstration effort will involve process development to identify buildings, and perform life cycle costing. A methodology will be designed for the uniform collection, documentation, and analyses of the resulting data. Careful monitoring of data throughout the demonstration phase will ensure accuracy.

BENEFITS:

Assessment results will identify technologies for potential use in follow-on demonstration efforts. Demonstration results will be used by the Federal Energy Management Program (FEMP) to assist the Federal sector to meet its required energy consumption goals and accelerate the adoption of energy efficient technologies in the Federal sector nationwide.

PARTNERS AND RELATED ACTIVITIES:

This effort will involve close coordination between DOE, DoD and EPA. DOE staff, including FEMP and Office of Buildings Technology technical personnel will provide technical and life cycle costing support. DOE staff will include USA CERL Facilities Conservation Program, as well as other senior facility and environmental staff, to assist primarily in the planning process.

MILESTONES:

This project will be completed by the end of FY92.

FUNDING ($M):

	FY92
SERDP	2.3

<u>RESEARCH ACTIVITY</u>: Theodore E. Kapus, Office of Building Energy Research, CE-42, Conservation and Renewable Energy, USDOE, 1000 Independence Avenue, SW, Washington, D.C. 20585, (202) 586-9123.

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Solar Detoxification of DoD Explosives in Soil

OBJECTIVE:

Implementation of this proposal will establish the feasibility of using solar energy to destroy explosive liquids and powders dispersed in soil. Explosive-contaminated soil at military facilities is one of the Department of Defense's (DoD) most serious environmental problems. The U.S. Army estimates there are 5 million tons of explosive-contaminated soil at 26 Army munitions facilities in the United States. Current remediation cost is about $300/ton. The Army's goal is to find a method of cleaning the soil for $100/ton, for a potential savings of $1 billion.

APPROACH:

A bench scale experiment would be conducted using solar energy to destroy mixtures of explosives common to DoD facilities. The solar process would then be compared to other conventional and innovative processes, including incineration. Solar energy has been shown capable of destroying many hazardous chemicals using two complementary effects unique to solar energy. High energy photons in the ultra-violet and visible portions of the solar spectrum are capable of breaking chemical bonds in a quantum process while moderate energy photons in the infrared portion of the spectrum provide thermal energy that result in chemical destruction through thermal processes. The combination of quantum and thermal effects has been shown to destroy chemicals at a higher rate, and with fewer hazardous byproducts than usually seen with incineration.

BENEFITS:

This effort could result in a method of removing explosives from soil at a cost much less expensive and with fewer products of incomplete reaction than conventional methods. This could help the Army meet its goal of reducing clean-up costs at its bases by $1.0 billion.

PARTNERS AND RELATED ACTIVITIES:

The U.S. Army Toxic and Hazardous Materials Agency, EPA, and DOE/CE are currently cooperating in an effort to demonstrate the use of solar energy for the detoxification of hazardous organic wastes in soils. Since many aspects of the technology would be the same, this proposed effort would gain the leverage of the existing project. Recent experiments at the National Renewable Energy Laboratory and the University of Dayton have shown that dinitrotoluene and nitrobenzene are excellent absorbers of solar energy. These results provide a strong indication that explosives can be destroyed by solar energy.

MILESTONES:

Work funded by this activity will be completed by the end of FY92.

FUNDING ($M):

	FY92
SERDP	1.0

RESEARCH ACTIVITY: Frank Wilkins, Office of Building Energy Research, CE-42, Conservation and Renewable Energy, USDOE, 1000 Independence Avenue, SW, Washington, DC 20585, (202) 586-1684.

RESEARCH PROPOSAL SUMMARY

RESEARCH TITLE: Supercomputer Procurement, Installation, and Operation to Support the Arctic Region Supercomputing Center (ARSC).

OBJECTIVE:

Establish an Arctic Region Supercomputing Center as directed by P.L. 102-72. The ARSC would support DoD and other federal agencies, the academic community and the grantee organization as appropriate. Develop requirements and specifications for the supercomputer. Initiate procurement and installation during FY 1992.

BACKGROUND:

Public Law 102-172 concerning appropriations for the DoD for FY 1992 states: "That of the funds appropriated in Public Law 101-510 (Nov. 5, 1990) for RDT&E, Defense Agencies, $25,000,000 provided for SERDP shall be obligated for the procurement, installation and operation of a supercomputer to support the Arctic Region Supercomputing Center."

APPROACH:

Pursuant to the authority granted by P.L. 101-510 (10 U.S.C. 2903[c]) which authorizes the Executive Director of the SERDP to enter into contracts and other agreements in an amount equal to, or in excess of $500,000 as approved by the SERDP Council, a grant under which the University of Alaska (UA) will serve as the owner, operator and administrator of the ARSC on behalf of the DoD, will be executed. The ARSC will be operated to serve DoD and national needs. The DoD will be entitled to 25 percent of the annual available CPU time on the ARSC systems at no charge.

BENEFITS:

The supercomputing capability will support global change and other research proposed under SERDP requiring supercomputer capability.

PARTNERS AND RELATED EFFORTS:

The capability provided by the ARSC will directly assist the execution of SERDP proposals concerning global environmental change.

MILESTONES:

Obligate procurement	FY 92
Install hardware	FY 93
Initiate shakedown	FY 93

FUNDING:	FY92	FY93
Procurement/Installation/Shakedown	25.0 M	0.0

RESEARCH ACTIVITY: Dr. Robert B. Oswald, Executive Director, SERDP, (202) 272-1839.

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OTHER		
Technology Projects	Pg.	Funding $(000)
Research to Characterize Environmental and Health Problems Associated with Defense-Related Operations (EPA)	225	6,200
Development of Manuals of Practice on Innovative Technologies (DoD/EPA)	228	250
Review of Environmental R&D Requirements, Identification of Functional Responsibilities, and Development of a Long Term R&D Strategy (HQUSACE)	231	250

Total Other Programs = $6,700

RESEARCH PROPOSAL SUMMARY

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MILESTONES:

Obligate procurement	FY 92
Install hardware	FY 93
Initiate shakedown	FY 93

FUNDING:	FY92	FY93
Procurement/Installation/Shakedown	25.0 M	0.0

RESEARCH ACTIVITY: Dr. Robert B. Oswald, Executive Director, SERDP, (202) 272-1839.

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Research to Characterize Environmental and Health Problems Associated with Defense-Related Operations

OBJECTIVE:

The initial objective and focus of this proposal is to develop and field-evaluate, in concert with DoD and DOE, a suite of scientifically defensible exposure-hazard-risk characterization/assessment methodologies, with supporting chemical fate and effects data bases, advanced monitoring techniques, and site sampling protocols. The goal is to develop reliable cost-effective environmental management and pollution prevention strategies for operational bases, and restoration or closure of facilities with safe return to private or commercial use. The longer-range objective is to incorporate more comprehensive stress factors and environmental endpoints into the risk characterization-management/mitigation/restoration design process, to include: habitat-land use, landscape design; game and endangered species population health, biodiversity, ecoindices; and reduction of emissions of stratospheric ozone-depleting materials and greenhouse gases.

APPROACH:

Several EPA research laboratories and field assessment offices have extensive experience and ongoing research efforts which can be effectively leveraged to produce rapid progress toward the started objectives. Most already have working relationships with DoD and DOE research organizations such that chemical stressors of concern and needed design and evaluation assessment/characterization techniques have been identified and structured herein into a well-coordinated program addressing the highest priorities.

EPA's operational approach, therefore, will be mainly to utilize its exiting research facilities and support cooperators, building upon to the maximum extent possible ongoing EPA programs such as the Ecological Risk Assessment Research Program, IRIS, the Global Change Research Program, and the Environmental Monitoring and Assessment Program, plus its core efforts in pollutant transformation, transport and measurement in air, surface water/sediments, and soils/groundwater, to provide the necessary basic understanding, data, measurement methods and assessment frameworks. EPA will then mainly utilize defense-related facilities and problem scenarios to parameterize and field-test these methodologies. Results will be used to refine both data bases and assessment algorithms, and to generate "user-friendly" interfaces and appropriate documentation, in concert with our SERDP partners, in order to facilitate effective technology transfer to the defense-operations management community.

The research proposal will be divided into two components, exposure (stress) assessment and hazard identification-effects characterization and assessment. A summary of the major activities planned in each of these components follows.

A. Exposure (Stress) Assessment Methods

- Development and field evaluation of advanced sampling and measurement techniques for determining human and ecological exposures to include: geostatistical approach for soil/aquifer sampling; real-time monitoring of micro-organisms and chemicals in water; and biomarkers.

- Development and field-testing of improved descriptions of chemical (and greenhouse gas) mixing/dispersion and chemistry/fate in the atmosphere.

- Development and field-evaluation of comparative quantitative methods to relate land use, land management, and defense operations to ecological damage and net greenhouse gas emissions.

- Development and application of linked multimedia (air-soil-surface water-ground water-biota) chemical fate/exposure models and data bases for evaluating alternative management/cleanup options at defense-related facilities.

B. Hazard Identification and Effects Characterization/Assessment Methods

- Development and field evaluation of a suite of advanced effects indicators for both problem identification and cleanup monitoring to include: phytoplankton fluorescence productivity techniques for estuarine waters and aquatic organism acute/chronic toxicity and teratogenicity assays.

- Development of an integrated health risk information system tailored for defense-related chemicals.

- Development and documentation of prototype assessment case studies; e.g., remediating radioactive wastes and operational impacts on coastal wetlands and the resulting influences on estuaries' productivity.

BENEFITS:

The project in this report will provide opportunity and stimulus for EPA, DoD, and DOE to share data, methodologies and experience relevant to the successful design of safe, cost-effective environmental management, pollution prevention and restoration strategies for defense-related operations--whether for continued facility operation, or closure and return to commercial use. Substantial cost savings should be realized since existing research programs of all participants will be leveraged and built upon. Finally, but not the least significant, is the potential to integrate and "standardize" sampling, measurement and assessment methodologies across agencies, particularly EPA, DoD, and DOE, which could materially accelerate progress toward cleanup and improved management of longstanding problems.

PARTNERS AND RELATED ACTIVITIES:

Many specific activities under this proposal have already been coordinated with DoD researchers and facility managers, as well as DOE and other EPA researchers. Principal DoD contacts include: U.S. Army - Biomedical Research and Development Laboratory, Ft. Dietrich, Maryland; U.S. Air Force - Engineering and Services Center, Tyndall AFB, Florida; and U.S. Navy-Medical Research and Development Command and Medical Research Institute, Bethesda, Maryland. Principal DOE contacts include Oak Ridge National Laboratory and Battelle Pacific Northwest Laboratory.

MILESTONES:

Exposure (Stress) Assessment Methods

- Research report on geostatistical soil sampling site characterization methods, real-time water monitoring techniques, and DNA fingerprint biomarkers for assessing human and environmental exposure at defense-related facilities.

- Research report detailing comparative environmental conditions/endpoints, including biogeochemical cycling, as a function of land use-military operations at selected, large (heavily impacted) military facilities.

- Modeling manual detailing improved air dispersion/chemistry and linked air-soil-surface water-groundwater-biota chemical fate modules and resulting GIS/DBMS-based ecological exposure assessment framework for defense-related facility environmental management or restoration.

Hazard Identification and Effects Characterization/Assessment Methods

- Handbook - Updated effects indicators and assays.

- Manual - Prototype computerized "military IRIS" or MIRIS, including first group of DoD highest priority chemicals.

- Prototype Case Studies Handbook - Global Environmental Strategies, European Base Restoration, Rad Waste Remediation, etc.

FUNDING ($M):

	FY92	FY93	TOTAL
SERDP	6.2	2.0	8.2

RESEARCH ACTIVITY: Carl R. Gerber, Office of Research and Development (RD-674), United States Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, FTS 260-8821; Fax 260-0552.

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Development of Manuals of Practice on Innovative Technologies

PURPOSE:

a. The U.S. Environmental Protection Agency (EPA) with the support and technical advance of the Department of Defense (DoD) will develop manuals of practice on eight innovative technologies through the award of a cooperative research agreement to the American Academy of Environmental Engineers. These innovative technologies have potential for permanent treatment of contaminated waste sites at DoD installations at a lesser cost than standard technologies. An interagency agreement will be developed.

b. This agreement establishes a mechanism by which DoD can contribute to the development of these manuals which will establish parameters for the operations of innovative technologies.

c. It is in the best interest of the government to implement this agreement as:

(1) DoD and EPA are both major users of innovative treatment technologies for hazardous site clean-up. Without standards established in a manual of practice, the government has little or no way to evaluate the performance of submitted designs and proposals. Consequently, the government has no way of determining liability of a contractor or vendor in the design and/or construction of an innovative technology.

(2) DoD and EPA, through the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) have been directed by Congress to consider innovative technologies, wherever possible.

(3) The proposal by AAEE would provide the professional consensus based manuals of practice that are needed to become industry standards.

(4) The eight manuals could not be written and published by the government in the time period of 2 years specified by the cooperative agreement to be awarded by EPA.

BACKGROUND:

a. Due to the overlap and similarities of the environmental missions of DoD and EPA and the call for cooperation and consultation between the agencies, EPA will develop, through a cooperative agreement with AAEE, manuals of practice on eight innovative technologies that will be published and used by DoD and EPA.

The manuals will serve to document the standards for when innovative treatment technologies can be used in response actions. Consequently, they will serve to enhance the ability of the agencies to select permanent and alternate/innovative treatment technologies for response actions. These manuals are responsive to the following chapters or sections of CERCLA:

(1) Section 121(b) of CERCLA requires remedial actions where treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants and contaminants is a principal element are to be preferred over remedial actions not involving such treatment... The President shall conduct an assessment of permanent and alternative (innovative) treatment technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility or volume of the hazardous substance, pollutant, or contaminant.... The President shall select a remedial action that is protective of human health and the environment, that is cost effective, and that utilizes permanent solutions and alternative (innovative) treatment technologies.

(2) Section 105(a) of CERCLA requires in the National Contingency Plan standards and testing procedures by which alternative or innovative treatment technologies can be determined to be appropriate for utilization in response actions.

(3) DoD is also responsible under Chapter 160 2702 (a) and (b) for testing, evaluation and field demonstration of any innovative technology, processes, equipment or related training devices which may contribute to establishment of new methods to control, contain, and treat hazardous substances, to be carried out in consultation and cooperation with (and to the extent possible in the same manner and standards as) testing, evaluation and field demonstration carried out by the Administrator of EPA. Development, collection, evaluation and dissemination of information is to be carried out in cooperation and consultation with EPA.

b. EPA held a workshop in October 1990 in conjunction with the National Advisory council on Environmental Policy and Technology. Sixty-five representatives from engineering firms, professional organizations, state environmental agencies, universities and Federal Agencies attended the workshop. The purpose of the workshop was to develop an agenda to reduce barriers to the use of innovative technologies. Fourteen action items came out of the workshop. At the top of the agenda was the need to develop a standard set of operating parameters for generic and site-specific applications of each technology. The workgroup proposed that a panel of experts for each technology be identified to define specific parameters, establish the current limits of each parameter, and formulate specific questions to obtain the information needed to evaluate innovative technologies.

The workgroup further determined that all interested parties must be represented to ensure that the information provided is satisfactory to the whole community using the data. Without this type of consensus-based document, engineers and scientists will remain apprehensive about selecting and using innovative technologies.

AAEE submitted a proposal to EPA in July 1991 to produce a set of manuals of practice on the following innovative treatment technologies: thermal destruction, vacuum extraction, bioremediation,

solidification/stabilization, soil washing/flushing, chemical extraction, chemical destruction, thermal desorption.

On June 5, 1991, EPA sent a letter to Mr. Baca, Deputy Assistant Secretary of Defense (Environment) requesting joint DoD participation in the project.

SCOPE OF WORK: The principal areas of work for the cooperative agreement will be:

a. compilation of references of innovative technology;

b. organization and presentation of projects to the user community;

c. development of draft manuals of practices by eight task groups composed of five technical experts selected by the steering committee;

d. two-stage technical review of the manuals of practices;

e. two revisions of drafts of the manual of practices;

f. preparation of camera-ready copies of each manual of practice to be submitted for DoD printing and distribution.

DURATION OF AGREEMENT: Specific schedules for completion of tasks are specific in the attached proposal. Completion on the Cooperative Agreement is September 30, 1993.

FUNDS: The Department of Defense will provide funding to the EPA for work under a cooperative agreement with AAEE and pursuant to this agreement not to exceed $250,000 for fiscal years 1992 and 1993. Work to be performed pursuant to this agreement is contingent upon final approval of funding by DoD. DoD retains its normal contract oversight authority for these funds and EPA will return unobligated or unexpended funds to DoD at the expiration of this agreement.

RESEARCH ACTIVITY: Jim Marsh, OASD(E), 400 Army Navy Drive, Room 206, Arlington, VA 22202, (703) 695-8360; fax (703) 697-7548.

DETAILED RESEARCH PROPOSAL

RESEARCH TITLE: Review of Environmental R&D Requirements, Identification of Functional Responsibilities, and Development of a Long Term R&D Strategy

OBJECTIVE: DoD has many activities engaged in RDT&E in support of weapons systems acquisition. Most R&D activities addressing environmental quality take place within the Services with little DoD coordination beyond 6.3a and limited transfer of technology within the Department or with other federal agencies and the private sector. This proposal is to identify R&D appropriate for DoD long term environmental needs, functional areas within DoD long term environmental needs, functional areas within DoD to manage the program to include basic S&T, as well as, field implementation, and the required level of oversight and the level of resource requirements necessary to support the program. The end product of this effort will be a environmental R&D strategy to guide the Department into the next century.

APPROACH: Identify those activities within DoD requiring new environmental technologies, identify environmental R&D requirements, propose management approaches within DoD to assure that adequate technology is developed responsive to user needs and that technology is shared with other federal agencies and the private sector. A DoD team will recommend to OSD an appropriate organizational structure to manage the R&D program and appropriate funding levels for performance of R&D. They will also develop a detailed strategy for acquiring technology maximizing the use of cooperative research and development agreements with other federal agencies and the private sector. The strategy shall also incorporate management recommendations contained in Defense Management Review Reports on Environmental Programs and recommendations made by the Environmental Response Task Force and the Multi-Agency Experts Group. The strategy will provide for technology development in response to user needs and provide for transfer to the user of proven technology in a form amenable to implementation without further testing or development.

PARTNERS AND RELATED ACTIVITIES: This work should be fully coordinated with other federal agencies and all defense activities and should build upon existing programs and maximize use of other resources.

MILESTONES:

Identify R&D requirements	March 92
Develop a program planning process	September 92
Recommend program structure	October 93
Issue draft strategy	December 93
Issue final strategy	February 92
Review activities and modify strategy as necessary	Continuous

FY92 FUNDING ($K): 250

RESEARCH ACTIVITY: Robert B. Oswald, HQUSACE, CERD-ZA, 20 Mass. Ave. NW., Washington DC., 22301-1000. PHONE: 202-272-1839; FAX: 202-272-0907.

STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM (SERDP)

PHASE II

REMOTE

SENSING

REMOTE SENSING		
	Phase II	
Technology Projects	**Page Number**	**FY 92 ($000)**
Multispectral Research and Development for Environmental Analysis and Mapping	1	400
Deep Permafrost Borehole Sites in Alaska	4	450
Analysis of Submarine Acquired Ice Draft Data	6	250
ARMY TOTAL		**1,100**
Numerical Sensitivity Studies for the Design of an Ocean Observing System	8	200
Instrumentation Development-Drifting Buoys	10	700
Marine Mammal Studies	12	300
Regional Time Series Surveys	15	300
Analysis of Submarine Acquired Ice Draft Data	16	100
DoD Global Change Research Program	17	100
NAVY TOTAL		**1,700**
Remote Sensing and In-Situ and Laboratory Measures for Assessment of Atmospheric Pollution from USAF Operations	18	320
Atmospheric Radiance Algorithms for Global Remote Sensing	20	320
AIR FORCE TOTAL		**640**
TOTAL		**3,440**

PROJECT: MULTISPECTRAL RESEARCH AND DEVELOPMENT FOR ENVIRONMENTAL ANALYSIS AND MAPPING

OBJECTIVE: The objective of this program is to develop technology to support environmental analyses using airborne and spaced-based multispectral systems. The proposed program will 1) expand current MSI databases to include environmental parameters for specific environmentally critical areas such as the Chesapeake Bay, various coastal wetlands, etc; and (2) develop a system to analyze imagery for temporal environmental monitoring and spatial mapping. The system will be capable of processing satellite and aircraft multispectral imagery with significantly improved classification performance.

APPROACH: Software developed at the U.S. Army Topographic Engineering Center (USATEC) will be examined for use in analysis of environmentally sensitive habitats specifically land cover mapping (LCM) and change detection (CD) for environmental analysis., Capabilities for classification will be improved by implementing suitable spectral/spatial (S^2) classifiers. Rather than analyzing the military aspects of the terrain as is currently done, the software would be used to analyze environmental aspects. Environmental factors to be considered include various types of wetland ecotones, terrestrial and aquatic habitats and other areas to be defined over time. The resulting capability would have three goals: (1) database creation, (2) data analysis (3) product generation. A multispectral database will be created drawing from existing database at USATEC and other Government organizations. The subsequent data analysis would be Geographic Information System (GIS) dependent and be designed to allow the most flexible analysis possible without compromising ease of use. The system will use enhanced semi-automated multispectral software (identified in a prior TEC effort) adapted for environmental analysis. A layered approach to LCM and CD will also be considered , whereby each scene element has multiple class levels accessible in a GIS-type environment that allows a users to conduct Boolean analyses about the environment. This effort includes: (1) developing remote sensing system analysis techniques for collecting the data including modifying software to model MSI for use in the analysis; (2) demonstrating the capabilities of the system yo support environmental impact assessments, (3) identifying multispectral imaging parameters which define spectral and spatial resolution requirements to support environmental change detection as well as sensor requirements to be used in the design of environmental data gathering satellites and aircraft.

BENEFITS: This program could assist counternarcotics efforts as well as global change research efforts being conducted by NASA under the Mission-to-Planet-Earth program. Current programs are not adequately resourced to support development of multispectral

imagery (MSI) technology for environmental analyses incorporating spaced-based remote sensing systems. This effort could provide a centralized, MSI-derived environmental data base on a continuous basis, as well as software for environmental change detection. The enhanced multispectral exploitation software/hardware system will increase the classification and positioning accuracy of land cover mapping. Accuracy will play an increasingly important role in evaluating the success of various environmental statutes; e.g. the Chesapeake Bay Act, and the reauthorized Clean Air Act. Additionally, multispectral data will provide the basis for optimizing the design of satellites and aircraft which collect spectral and spatial information needed to detect environmental hazards and change.

PARTNERS AND RELATED ACTIVITIES: U.S. Army Corps of Engineers, Environmental Protection Agency (EPA), and the U.S. Fish and Wildlife Service will be involved because of their interest in the enforcement of environmental policy. NASA and the U.S. Geological Survey (USGS) have developed the Land Analysis System (LAS) software for the SUN/UNIX and VAX/VMS environments that have supported USATEC's prior multispectral activities. TEC has recently complete a study of enhances semi-automated multispectral techniques. Related activities include the evaluation of the Persian Gulf oil spill and wetlands loss in Northern Virginia.

MILESTONES:

FY93 Identify study area where msi data could provide needed data for analysis. Review literature on previous work. Conduct feasibility study of spectral remote sensing f wetlands to assess cumulative impacts of dams and pollution.

FY94 Examine available image analysis hardware/software systems/workstations and procure best system. Begin filed spectral measurements of selected site to correlate remotely acquired signatures with *in situ* measurements measuring such parameters as seasonal wetland signatures.

FY95 Demonstrate MSI environmental change assessment of selected site.

FY96 Complete development of a computer-assisted Environmental Impact Assessment capability and an MSI environmental exploitation system.

FY97 Define multispectral imaging parameters and develop specifications for future environmental data gathering satellites and aircraft.

FUNDING ($M)

Type	FY92	FY93	FY94	FY95	FY96	TOTAL
6.1	0.3	0.2	0.1	0	0	0.6
6.2	0.1	1.4	1.8	1.6	1.2	6.1
TOTAL	0.4	1.6	1.9	1.6	1.2	6.7

ACTIVITY: U.S. Army Topographic Engineering Center (ATTN: CETEC-GL-T), Fort Belvoir, VA 22060-5546, 703-355-2802

PROJECT: DEEP PERMAFROST BOREHOLE SITES IN ALASKA

OBJECTIVE: Establish 3 deep borehole field sites in Alaska as part of an international program to monitor the effects of global climate change in the circumpolar permafrost regions. The U.S. has no dedicated sites to systematically observe permafrost thaw/thermal degradation due to a feared general warming. After drilling of the 200m holes and installation of energy flux and temperature instrumentation, these permafrost sites will yield deep ground temperature data reflecting changes in the surface climate that have occurred over the last 100 years. These data can be used to interpret global climate model predictions and allow cryospheric temperature and energy flux models to be calibrated with field data. After the one-time initial cost of the field site installation, monitoring and analysis will be carried out by RDT&E funds in the USACRREL program.

APPROACH: Permafrost (20% of the world land area) contains in its present thermal regime a history of climate change from past centuries; this can be recovered by analyzing deep borehole temperatures. USACRREL, US Geological Survey, Geophysical Institute of Alaska, Geological Survey of Canada, Permafrost Institute (Russia), and Lanzhou Institute of Geocryology (China) have had discussions to combine resources for the development of a circumpolar network of monitoring sites. These countries contain most of the world's permafrost. Agreement was reached on the field sites and overall circumpolar monitoring program necessary to give a clear picture of the relation of permafrost to global climate change. General Circulation Models do not adequately incorporate atmospheric/cryospheric energy fluxes for the huge permafrost regions. It is proposed to establish three field sites representing permafrost zones in Alaska, with additional sites in the other countries. Each site will require drilling and logging a 200m deep borehole, with minimal surface disturbance, instrumented for surface and ground temperatures, moisture and energy flows. Within the context of global change and the permafrost regions, the sites will be monitored for many years after site installation.

BENEFITS:

1) Establishment of U.S. portion of circumpolar network of permafrost monitoring sites.

2) International cooperation on quantitative interpretation of climate changes over past 100 years in permafrost zones, with simultaneous northern-hemisphere circumpolar measurements in several countries.

3) Early warning of permafrost thawing/thermal degradation which can jeopardize all systems now built on permafrost. These include strategic DOD facilities such as airfields, radar sites and

structures of all kinds, as well as vital national interests exemplified by facilities such as the Trans-Alaska Pipeline.

MILESTONES:

		FY
Task 1.	Drill and instrument first Alaska site: Poker/Caribou Creeks	92
Task 2.	Establish second Alaska field site	92/93
Task 3.	Establish third Alaska field site	92/93
Task 4.	Coordinate international sites and instruments	92/93

FUNDING ($K):

FY92	FY93	FY94	FY95
450	400	750	300

ACTIVITY: Dr. V. J. Lunardini, CECRL-EA, (603) 646-4326, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH 03755-1290

PROJECT: ANALYSIS OF SUBMARINE ACQUIRED ARCTIC ICE DRAFT DATA

OBJECTIVE: The objective is to screen and analyze 30 years of existing submarine sonar profiles of ice draft collected in the Arctic basin to establish a climatology of ice thickness distributions to assist in the study of global climate change.

APPROACH: Since 1958, submarines have been transiting the Arctic basin on military missions and collecting profiles of ice draft primarily for operational purposes. The vast majority of these profiles have never been analyzed in an organized fashion because they are considered sensitive to national security. Recently,. much of the data from non-sensitive areas of the Arctic have been declassified. The sonar ice draft data are, without question, the only existing source of consistent historical ice thickness information. Analysis of this past information is essential to establishing an ice thickness climatology in the Arctic to begin a long term climate monitoring program.

Data from 40+ Arctic submarine missions will initially be screened to determine the unclassified portions of missions with data of sufficient quality to warrant analysis. Selected data will be analyzed to produce statistics suitable for the establishment of a climatological ice thickness data set. This program will be conducted jointly with the Navy.

BENEFITS: Current projections of global warming suggest a highly sensitive signal in the polar regions which is likely to be best manifested in changes in extent and thickness of the global sea ice cover. This program will make the best use of existing data to evaluate the effects of dynamic and thermodynamic processes influencing ice thickness and establish a base line from which climatic signals in the future may be detectable. The analyzed data will also provide a valuable data set for use for verification of ice forecasting models.

MILESTONES:

		FY
Task 1.	Screen and process selected profiles, minimizing and quantifying possible errors.	92
Task 2.	Generate relevant statistics, mean thickness, probability density functions, and pressure ridge distributions.	92
Task 3.	Establish regional and seasonal ice thickness data set compatible for future Navy-funded ice monitoring programs.	93

FUNDING ($K):

FY92	FY93	FY94	FY95
350	225	200	175

($250 Army, $100 Navy)

ACTIVITY: Army: Mr. S. F. Ackley, CECRL-RS, (603) 646-4258, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH 03755-1290; Navy: Mr. K. Ferer, (601) 688-4760, Naval Research Laboratory, John C. Stennis Space Center, MS 39590

PROJECT: NUMERICAL SENSITIVITY STUDIES FOR THE DESIGN OF AN OCEAN OBSERVING SYSTEM

OBJECTIVE: Develop a knowledge base needed for the design of ocean observing networks. Establish guidelines that can be employed on a regional basis to assure that ocean variability (time and space) is correctly represented in an optimal ocean monitoring system.

APPROACH: A substantial effort is being directed toward the development of ocean measurement capabilities. Data resulting from a multitude of measurement types, which include in-situ, drifting buoy and satellite sensors must be assimilated into predictive models of the ocean for nowcasting and forecasting. The best mix or combination of observations including their density and distribution must be established in order to develop efficient cost-effective networks.

This project will conduct sensitivity studies of ocean models to input data in terms of the accuracy and completeness of available data. We will generate simulated ocean data sets for use in the studies and conduct comparisons of results using error fields generated in these simulations then test the results against research quality data sets acquired through the field measurement programs such as SYNOP and REX. Guidelines and criteria will be established for the optimization of observations (i.e., What are the most effective sampling strategies? What are the prime considerations for an optimal observing network? And how should these observations be assimilated into models?).

BENEFITS: This effort will result in cost effective observing networks that are essential to monitoring ocean change. The models used to develop the information base for network design will also be available for the design of optimal observing systems. In addition, this research will provide a capability for large scale ocean simulations which are needed for Naval Warfare Systems design.

Our attempts to define or describe the ocean on the basis of available observations alone has produced limited realizations of ocean phenomenology and ocean variables. We will likely always be confined by, the cost of ocean observations, and it is, therefore, imperative that we employ available resources as efficiently as possible. A systematic assessment of the sensitivity of numerical models to input data and the methods employed in the assimilation of these data into the models is clearly needed. Various types of models, e.g., feature models and dynamic models, will be used in concert with improved numerical representations, such as, empirical orthogonal functions (EOFS) to enhance our ability to specify 3-D fields of these ocean variables.

PARTNERS AND RELATED ACTIVITIES: NRL and INO, working closely with the University of Washington have conducted numerical experiments for the assimilation of tomographic data into the DART model of the Gulf Stream. Efforts of this type would be continued to include other data types. A number of ONR funded PI's have been conducting specific studies relative to the sensitivity of models to data assimilation. These include the use of Kalman filters at MIT, Oregon State University and UCLA. Harvard University has been testing the sensitivity of QG and PE models to IES data. The INO has recently completed a data assimilation study of tomographic and altimetric data into a model of the Gulf of Mexico. This project would focus on the coordination of these related studies toward a common objective that would eventually lead to the design of observing networks.

MILESTONES:

FY92 Select models for sensitivity studies
FY92 Begin studies for simulated acoustic tomography data
FY93 Conduct observing system simulations for Atlantic data (AMODE)
FY93 Compare design results with experimental tomographic data

FUNDING ($M):

FY92 0.200

ACTIVITY: Mr. Robert Peloquin, Office of Naval Research, (703) 696 6462.

PROJECT: INSTRUMENTATION DEVELOPMENT-DRIFTING BUOYS

OBJECTIVE: Develop and deploy arrays of drifting oceanographic buoys to enhance ocean circulation and coupled ocean/atmosphere models for monitoring, assessment, and prediction of environmental change. Better definition of the ocean/acoustic/ meteorological structure of the ocean and air-sea interface using drifting buoys equipped with a variety of sensors will provide meaningful insights into global climate change while enabling significant improvements in one to thirty day forecasts in the Northern hemisphere.

APPROACH: Additional sensors will be developed to expand existing data collection efforts using satellite-reporting drifting buoys. Funding sought under this program will be used to enhance ongoing developmental work in oceanographic buoys to measure such parameters as sub-surface temperature structure, ambient noise, surface wind and wave conditions, barometric pressure, optical parameters, and air temperature.

A network of buoys will be deployed in conjunction with existing Navy programs and civilian global change research programs such as WOCE (World Ocean Circulation Experiment). The goal is to obtain a global coverage at 5 degree resolution for a periods of five years. Instruments deployed with funding requested here will contribute to that array as well as a number of process oriented upper ocean studies. The buoys will be deployed from patrol aircraft (P-3) and ships. The aircraft will be outfitted with wind, temperature, and pressure recording and transmission systems which will transmit data via satellite consistent with procedures for World Meteorological Organization/World Weather Watch data collection from commercial aircraft.

Data will be collected by satellite and communicated immediately to the Fleet Numerical Oceanography Center (FLENUMOCEANCEN) at Monterey, CA and to the Naval Oceanographic Office (NAVOCEANO) at the Stennis Space Center, MS. It will also go to the WOCE buoy data center for application of precise navigation and sensor calibration. From there, buoy data, and oceanographic and meteorological products derived from them, will be distributed worldwide to other centers via the Global Telecommunications Network (GTS).

Data will be monitored and quality controlled and the final data set will be archived for transfer to the United States and international oceanographic research community.

BENEFITS: This program will significantly benefit both oceanographic and atmospheric science programs, not only by the DoD, but by the national and international science community. Observations over the ocean are sparse at best and far too infrequent to initialize oceanographic, acoustic, and atmospheric

models for detection of submesoscale features.

The improvement in forecast skills by these models will have a profound impact on the Navy's ability to support the Fleet and Fleet Marine Force in naval warfare missions worldwide. Modern warfare in a changing political climate dictates that short and long term forecasts of environmental effects on platforms, weapons, and systems be timely and accurate. Emergence of stealth aircraft technology and proliferation of modern diesel-electric submarines (which are inherently stealthy) in the third world underscore the need for accurate environmental forecasts. Understanding the mechanisms of mesoscale and sub-mesoscale features in the air/sea environment is key to such support. The benefit of this program to climate change research is no less significant. Modeling of energy transfer at the air-sea interface is key to executing coupled eddy-resolving models and basin-scale circulation models, both of which are being pursued by the civilian research community.

PARTNERS AND RELATED ACTIVITIES: The Navy's oceanographic buoy program is conducted in close cooperation with several interagency and intergovernmental programs under the sponsorship of NOAA, WMO, IOC, IGOSS, IODE, etc. Examples include WOCE and TOGA. Implicit in these efforts is the Navy's partnership with NOAA's National Ocean Service.

MILESTONES:

		FY
-	Integrate new sensors on oceanographic buoys	92
-	Deploy buoys via aircraft over Northern Hemisphere in Atlantic and Pacific	92-93
-	Investigate interaction of air-sea parameters for models	92-93

FUNDING ($M):

FY92
0.70

ACTIVITY: U.S. Navy, Office of Naval Research, Dr. David Evans (703) 606-4112, Naval Research Laboratory, [redacted] 688-4760.

PROJECT: MARINE MAMMAL STUDIES

OBJECTIVE: Develop an understanding and data-base on the effects of low-frequency sound on marine mammals.

BACKGROUND: The Heard Island Feasibility Test (FY90-92) examined the feasibility of using the travel time of acoustic signals over long ocean paths to estimate the average temperature of the ocean. The Test put 57 Hz sound in the water in the south Indian Ocean during 26-31 January 1991; 18 sites were listening including the east and west coasts of the U.S. using U.S. Navy hydrophone facilities. The central acoustic questions of the feasibility test were the transmission loss over global acoustic paths, and the fidelity of the received signal. There is also a critical marine-mammal question: can these kinds of sounds be made in a way that does not harm the marine mammals, and how can the regulatory process be satisfied? For a potential ten-year global program, as proposed by DARPA, technology is needed such as new sound sources that are reliable and affordable, and the knowledge of the effects of low-frequency sounds on marine mammals must be enhanced to allow signals and methodologies to be designed that will have acceptable impacts.

This SERDP proposal addresses the marine mammal issue, motivated by the Heard Island Feasibility Test; however, any use of underwater sound to explore the ocean and its contents must be examined in light of the increasing regulatory environment and an increasing awareness of possible effects of such sounds on marine mammals and endangered species.

APPROACH: This SERDP effort concentrates on marine-mammal responses to low-frequency acoustic signals.

A marine mammal research program is being developed at ONR in cooperation with the National Marine Fisheries Service and the Minerals Management Service; the program is under the review of a joint panel from the Ocean Studies Board and the Committee on Hearing and Bioacoustics of the National Academy of Sciences. This program will specifically address the response of marine mammals to low-frequency coded signals, of the kinds used for Heard Island. The frequency range being explored is 50-1500 Hz so as to cover the likely kinds of systems that will be used for ocean studies. The program consists of laboratory studies with captive animals, field studies on "animals of opportunity" using attached "smart tags" and tracking by active and passive acoustics, and species behavioral studies at representative candidate sites for follow-ons to the Heard Island Feasibility Test. The program has only minimal funding in its current form; the SERDP funding will permit this to be an aggressive, broad and deep, and productive research effort.

This effort is coupled to but distinct from the marine mammal

monitoring program embedded within the DARPA program for a Heard Island follow-on. In that program, the marine mammals efforts will consist of surveys of animal number densities at the surface at the one or two sites being proposed for testing of new, deep, loud, low-frequency sound sources. In this program, the effort will look specifically at the response of the animals to the low-frequency sound, using tags attached to the animals and by watching the animals underwater using active and passive acoustic tracking. The work will not be restricted to the candidate sites for a global, long-range extension to the Heard Island program. The DARPA effort is incidental to the Heard Island acoustics program and may or may not be required to have incidental-take authorizations. This effort is specifically marine-mammal research and will be conducted under marine-mammal research permits from the regulatory agencies.

BENEFITS: Global ocean warming is an early and important indicator of global change from greenhouse gases. Some direct effects of ocean warming are increased sea level, changes in ocean circulation patterns, effects on weather, ability to absorb carbon dioxide from the atmosphere, and modification of the growth environment for ocean animal and plant life. In addition, the flywheel effect on warming of the planetary system is potentially substantial due to the great heat capacity of the oceans.

The baseline data from an acoustic, global ocean-monitoring program will provide constraints on numerical models of global change and ocean warming. The emerging science of global acoustics will allow broad-ocean exploration and relates strongly to current Navy efforts. This program will involve the very best of the academic researchers working closely with personnel of the Navy labs and associated industries.

Marine mammal studies are lagging severely behind our need to know more about them. The effects of low-frequency sound study will address what is arguably the most important open question regarding marine mammals and the intervention of man in the ocean.

Other efforts using low-frequency sound in the ocean, such as tracking of deep autonomous drifting floats, will also benefit from the enhanced understanding of the effects of such sounds on marine mammals.

The primary benefits will be the knowledge base that will allow the design and construction of acoustic devices based on known levels of possible harm to the marine mammals (these levels are not currently known), and an information base that will ease and speed the regulatory process that provides permits and authorizations for the use of sound in the ocean.

PARTNERS & RELATED ACTIVITIES: The principal partners in the agencies are the NOAA National Marine Fisheries Service and the Department of the Interior's Minerals Management Service. There are lesser interactions with DARPA and their efforts toward a follow-on to the Heard Island Feasibility Test, NSF and DOE, and other Navy components.

MILESTONES:

Develop advanced whale tags that have the capability to operate in deep sound channels, to detect ensonification of the whales, and to determine some physiological response of the animals.	FY92
Initiate laboratory studies of the effects of low-frequency sound on marine mammals.	FY92
Test the new whale tags.	FY93
Begin field efforts with the new tags.	FY93
Begin coordination with the DARPA efforts on marine mammal surveys.	FY93

FUNDING ($M): FY92 .30

ACTIVITY: Dr Melbourne Briscoe, Office of Naval Research, ONR Code 124, Arlington, VA; 703-696-5084.

PROJECT: REGIONAL TIME SERIES SURVEYS

OBJECTIVE: Provide coastal environmental boundary condition data and analysis with associated documentation/statistics necessary to support ocean environmental model testing and validation. Capitalize on DoI funded state-of-the-art technology employed to obtain the above data.

APPROACH: This program leverages a major DoI Mineral Management Service (MMS) program called Louisiana - Texas Shelf Circulation Study (LATEX), exploits capabilities uniquely developed by Navy (ONR), and designed to understand fundamental coastal dynamics issues important to civil and military operations, e.g. Anti-Submarine Warfare and Environmental Quality, et al. LATEX is a long term field effort that can be leveraged over many years. This effort will utilize moorings, bottom mounted sensors, and drifter technologies to gain time series data and analysis on a spatial scale appropriate to mutual agency objectives.

BENEFITS: Significantly increase understanding and utility of new coastal environmental data bases and forecast models. These data would provide a new baseline time series coastal data base and provide initial conditions to support operational forecasting and environmental quality projections. This program would also serve as a test bed for DoD, MMS, EPA and NOAA model development and verification. Development of state of the art measurement systems will increase the U.S. personnel and technology infrastructure. Unclassified technology developed here would immediately be made available to the civil user community.

With this modest one-time investment, a long term data set and analyses fine-tuned to military and civil needs will be realized.

PARTNERS AND RELATED ACTIVITIES: This effort will be closely coordinated with DoI (MMS), EPA and NOAA to effectively leverage the total investment. Known technologies would be applied, but new methods under development by DoI, NOAA, and other agencies would be incorporated.

MILESTONES:
FY 92
- Establish ties with the DoI LATEX managers; select academic, industrial, and federal laboratory performers.

FY 92/93
- Develop and deploy instrumentation suites; commence field work.

FUNDING ($M): FY92 - .30

ACTIVITY: Dr. Richard Spinrad, (703) 696-4120, Office of Naval Research, Arlington, VA 22217-5000.

PROJECT: ANALYSIS OF SUBMARINE ACQUIRED ICE DRAFT DATA

OBJECTIVE: Verify the utility of submarine sonar data for determining ice thickness distributions in the North Polar region, and establish a climatology of ice concentration/thickness distributions to address climate change questions. This is a joint SERDP program with Army CRREL.

APPROACH: Conduct a systematic investigation to analyze profiles of Arctic sea ice draft collected by submarines over the past three decades. These data will be screened for error estimates and compiled into regional and seasonal tables of the ice thickness distribution for the Arctic-Basin. Establish a baseline data set not available previously that can provide a guide for future monitoring programs (airborne, submarine, and satellite). This effort will contribute to Defense needs and global climate change research goals.

BENEFITS: Current projections of global warming suggest a highly sensitive signal in the polar regions, probably best manifested in changes in sea ice cover. This program will benefit research in these climate mechanisms by establishing baseline measurements against which climatic signals may be detected and provide verification data for Arctic sea ice forecasting models. The resultant improvement in ice forecasting will significantly enhance DoD warfare missions executed in polar regions. Finally, this funding will make effective use of a valuable data set which is an unexploited national resource.

PARTNERS & RELATED ACTIVITIES: Partnership with the Army Cold Region Environmental Laboratory (CRREL) and the Naval Research Laboratory (NRL) will be established. Related research is sponsored by DOD, DOC, NASA, and NSF under the U.S. Global Change Research Program.

MILESTONES: FY 1992/1993
Screen and process the sonar profile data set, establish an error analysis routine.
Systematic analysis of these data and reduction to ice thickness distributions.
Climatic data base of submarine derived ice thickness for comparison to other data sets and model outputs.

FUNDING ($M): FY 92 .200;
.10 (Navy) .10 (Army - via separate proposal)

ACTIVITY: Mr. Ken Ferer, (601) 688-4760, Naval Research Laboratory, Stennis Space Center, MS 39529-5004

PROJECT: DOD GLOBAL CHANGE RESEARCH PROGRAM

OBJECTIVE: Support DoD participation in the U.S. Global Change Research Program (USGCRP).

APPROACH: In FY 1992, DoD joined ten other Federal Agencies sponsoring "Focused" global change research. The DoD Focused program concurrently satisfies DoD mission requirements and USGCRP goals. DoD does NOT engage in USGCRP Budget Options and no new money is involved. SERDP funding will pay the Defense share of distributed agency contributions to support the Committee on Earth and Environmental Sciences (CEES) Subcommittee on Global Change (SGCR) activities for FY 1992/1993.

BENEFITS: In 1990, OSD recognized that potential global change issues could impact DoD missions and directed active participation in Federal Committees addressing this problem. Additionally, limited 'Focused' research in global change was encouraged. Consequently, DoD was represented in the CEES Global Change Committee, identified a modest DoD research program, and effectively leveraged the ongoing billion dollar plus federal research effort. As an indirect issue, the USGCRP is perceived in academia as a major intellectual challenge and attracts the best and brightest U.S. science minds. Participation by DoD allows a new access to this unique resource. Finally, committee representation allows the Department to act positively rather than react to issues potentially adverse to national security interests.

PARTNERS AND RELATED ACTIVITIES: Representatives from the Army and Air Force routinely support the Chief of Naval Research in his role as the DoD representative to the CEES Subcommittee. An integrated DoD program is presented to the ten other Federal Agencies participating in the USGCRP.

MILESTONES:

Continue DoD representation to the CEES Subcommittee
FY 92/93
on Global Change Research

Provide the required distributed agency contribution
FY 92/93
to the CEES Subcommittee on Global Change Research

FUNDING ($M): FY 92 .10

ACTIVITY: Commander Scott Sandgathe, Office of Naval Research - Code 11D, Arlington, VA 22271, (703) 696 4102.

PROJECT: REMOTE SENSING AND IN SITU AND LABORATORY MEASURES FOR ASSESSMENT OF ATMOSPHERIC POLLUTION FROM USAF OPERATIONS

OBJECTIVE: The goal of the research is to measure concentrations of pollutant species relevant to USAF operations, with emphasis on missile and aircraft engine emissions. In order to carry out this objective, laboratory, remote sensing, and in-situ programs are needed.

APPROACH: The approach combines a state-of-the-art mass spectrometry technique for measuring species concentrations and several established techniques in UV remote sensing. In the laboratory program, we shall measure rate constants for reactions important in the ion chemistry of the lower atmosphere, paying particular attention to reactions relevant to determining pollutant concentrations in the troposphere and stratosphere. We shall combine these measures with results from remote ultraviolet (UV) and in situ measurements to establish the chemical identities, abundances, and lifetimes of pollutant species. The species studied will be those relevant to such USAF operations as missile launches and flights of subsonic and supersonic vehicles in the atmosphere. The initial rate constant measurements will be made in an existing variable temperature selected ion flow drift tube. Use of this type of apparatus has provided most of the previous measurements of the chemical kinetics important in atmospheric ion chemistry. The chemistry in question, however, poses new challenges to laboratory measurements. It will b necessary to develop such techniques as a supersonic expansion ion source and improved sources of reactant neutral species at low temperature. For measurements at high temperatures, a new apparatus is just coming on line which will be able to reach temperatures higher than any previous device for studying ion chemistry. The laboratory kinetics measurement will then be combined with UV measurements and in situ ion composition measurements to derive the pollutant concentrations. Both currently used and developmental propellants can be examined, with particular attention given to chlorine species that are known to catalyze ozone destruction.

UV remote sensing techniques will be used in exploratory measurements of the emission and absorption from species in the plume and exhaurst of missile engines. This work, which is an extension of our previous measurements of missile plume intensities, will concentrate on spectral as well as spatial characteristics of the pollutants released.

BENEFITS: Missiles and jet aircraft generate pollutant species in their flight through the troposhere and stratosphere. In order to assess the environmental impact of such species, it is necessary to know the concentrations and the lifetimes of the foreign species and the chemistry which they underrgo in the atmoshpere. The research will make it possible to form a

coherent picture of the extent and type of pollution to be encountered in missile testing and launch. The same techniques can then be used to assess similar pollution from high performance aircraft operating at high velocity in the troposhere and stratosphere. The results of the measurements are expected to lead to improved procedures for monitoring and controlling the combustion processes and thus to minimizing pollutant emissions.

PARTNERS AND RELATED ACTIVITIES: Current organizations making in-situ ion concentration measurements are Georgia Institute of Technology and Max Planck Institute for Nuclear Physics, Heidelberg, FRG. Each of these groups has unique capabilities, and the choice of group to perform the initial phase of the study would depend on the environment to be studied. We have previously collaborated with these groups in order to combine our laboratory work with the field studies and to derive trace neutral concentrations. Several DOD facilities will be involved since the measurements will be made in conjucntion with launches and flights made for other purposes.

MILESTONES:

JUN 92	Complete improvements on laboratory ion chemistry apparatus
JUL 92	First rate measurements with new ion source and new gas inlets
FEB 93	First in situ and remote measurements at Edwards AFB
SEP 93	Final report and recommendations for future work

FUNDING ($K):

FY 92
320

ACTIVITY: PL/GP, Dr. A.A. Viggiano, DSN 478-4028, Hanscom AFB

PROJECT: ATMOSPHERIC RADIANCE ALGORITHMS FOR GLOBAL REMOTE SENSING

BACKGROUND: The current unique PL/GP atmospheric transmittance-radiance codes (LOWTRAN, MODTRAN, FASCODE plus high-altitude codes like ARC/AARC and SHARC) have been designed to provide predictive capabilities for electro-optical design, target contrast, remote sensing and surveillance. The OSD/DOD Atmospheric Transmission Plan (signed in 1978 and 1982, reapproved as sufficient in 1988) assigns responsibility for developing and maintaining atmospheric radiance and transmittance algorithms for the tri-Services to the Air Force.

OBJECTIVE: Extend the GPO radiative transfer codes (MODTRAN, FASCODE, ARC, SHARC) to specifically address remote sensing issues occasioned by environmental changes; work will include:
1) Upgrade existing radiative transfer codes to incorporate both anthropogenic species and improved particulate descriptions.
2) Design practical generic inversion algorithms based on moderate to high spectral resolution including nonequilibrium (non-LTE effects).
3) Develop improved parameterizations of radiative and trace constituent effects to insure more effective response of AF codes.

APPROACH: With the release of FASCOD3 (March 1992), the GP family of codes have a demonstrated ability to include CFC (fluorocarbon) signatures. FASCOD3P, coupled with the CIRRIS-1A data, has demonstrated the importance of the CFCs in the 10-12 micron window. These new measurements clearly indicate that CFC signatures are now comparable in magnitude (all a factor of 10 over background) to HNO_3, a prime radiance contaminant included in the codes since 1978. Such contamination is particularly important for paths near the tropopause, typical for lines-of-sight for Theater Missile Defense scenarios. Using GP codes as a foundation:

1) Add IR CFC cross-section signatures to MODTRAN.

2) Design generalized inversion algorithm for remote sensing and data analysis compatible with moderate spectral resolution data.

3) Provide current and projected concentration profiles for CFCs and other pollutant species.

4) Improve CO_2 spectroscopy at 15 and 4.3 microns to clarify role in temperature inversions

5) Investigate the effects of altered radiative fluxes brought about by changes in trace constituent profiles.

6) Determine implications of upper atmospheric non-LTE radiative

effects on remote sensing and retrieval algorithms. Specifically, determine the contribution of altered radiative fluxes to Greenhouse warming.

BENEFITS: All these efforts are recognized as important components for maintaining state-of-the-art atmospheric radiance modeling capability. They will augment the DOD electro-optical modeling requirements for all the Services, upgrading target contrast descrinimation both spatially and spectrally, particularly in the middle and upper atmosphere where new theater opportunities have emerged. In addition, the improvements will provide DoD and other environmentally concerned associates (DOE, NOAA, NASA, etc.) with efficient tools for predictions, interpretation and validation of potential environmental change effects. By supporting both military, sensor systems and global change, as well as the potential relationship between the two, the radiative transfer codes upgrade provides critically needed support called for under the DOE/NRL SERDP I proposal: "Joint DoD and DOE Atmospheric Remote Sensing and Assessment Program for Global Climate Change." These codes are already being used for simulation studies by both NRL and DOE. Finally, the upgraded codes will provide needed analysis tools for CIRRIS, MSX, and potential TMD measurement scenarios.

PARTNERS & RELATED ACTIVITIES: Because of their long history of cooperative involvement, the PL/GP radiance-transmittance codes are currently used by most atmospheric research arms of the military, government (USA and others), universities, and corporations. Commercial versions of the codes are also sold under the Technology Transfer Act. PL/GP has established a Cooperative Research and Development Agreement (CRDA) specifically for its radiance-transmittance codes which have provided rapid access to the civilian scientific community. In addition, patents have been pursued for two codes, one awarded and the other filed. Particular continued involvement is expected from the DOE ARM (Atmospheric Radiance Measurement) Program, and the Naval Research Lab. Additional Canadian DREV and University of Wisconsin involvement on inversion algorithm development, particularly as coordinated with lidar returns, is expected. Other important partners include the CIRRIS, MSX, and TMD teams.

MILESTONES:

FY

92 Provide current and projected profiles of anthropogenic modulation of constituents (CFCs, CO2, HNO3, etc.) plus improved aerosol volcanic/high alt) profiles (all preliminary)

93 Include fluorocarbon (etc.) x-sections (IR), developing

appropriate spectral band models, etc.

93 Design, test, and validate banc model inversion codes based on current high-resolution algorithms

93 Improve CO_2 line shape spectroscopy at 4.3 and 15 microns

93 Determine influence of non-LTE radiative effects on remote algorithms

<u>FUNDING HISTORY AND RELATIONSHIP:</u>

PROGRAM ($K)	FY 92
FY 92 FUNDING:	320

<u>ACTIVITY:</u> PL/GPOS, G.P. Anderson, DSN 478-2335
R. Picard, DSN 478-2222

INSTALLATION

RESTORATION

AND

WASTE

MANAGEMENT

INSTALLATION RESTORATION AND WASTE MANAGEMENT		
	Phase II	
Technology Projects	**Page Number**	**FY 92 ($000)**
Innovative Treatment of Contaminated Groundwater at McClellan Air Force Base (AFB), Davis, California	1	1,100
Environmentally Safe Disposal of Explosive Wastes	3	1,700
Rapid Screening Reversible Sensor for Environmental Screening and Monitoring	6	500
DOE TOTAL		**3,300**
Development, Evaluation and Application of Biomarkers for Munition Exposure Monitoring	9	180
Develop Mathematical Models for Subsurface Flow and Contaminate Transport	15	720
Elimination of DU in KE Penetrators	17	450
Elimination of Chlorinated Solvent Use in Red Phosphorus (RP) Munitions Manufacture	19	230
Alternate Processes for Liquid Propellant Manufacture	21	450
Cadmium Plating Alternatives	24	270
Environmentally Acceptable Metal Cleaning	25	230
Investigation of Aqueous Cleaning System to Replace CFC Vapor Degreaser	26	120
Replacement for Chlorinated Solvents in Rocket Motor Primers & Tackifiers	27	250
ARMY TOTAL		**2,900**

INSTALLATION RESTORATION AND WASTE MANAGEMENT		
	Phase II	
Technology Projects	**Page Number**	**FY 92 ($000)**
Oil Spill Transport Prediction System	28	300
Naval Ship Systems Radiological Control Detection	31	500
Laboratory and Field Marine Bioindicator Systems	33	600
Shipboard Secondary and Tertiary Bilge Waste Treatment System	35	300
Navy Shipboard Hazardous Materials Reduction	37	300
Navy Non-Ozone Depleting Technology Clearinghouse	39	200
Ordnance Use/Disposal Risk Evaluation/Modeling	41	100
NAVY TOTAL		**2,300**
CFC, Hazardous and Toxic Materials Elimination	42	450
Aerospace Systems Guidance and Control CFC Elimination Program	43	500
Radio Frequency Thermal Heating of Soil to Remove Volatile Organic Compounds	45	860
Manufacturing Technology for Large Aircraft Robotic Paint Stripping (LARPS)	47	650
Chemical Tank Rejuvenation	48	250
Advanced Mixing Technology for Low NOx	50	350
Fiber Optic Monitoring System Development	52	300
AIR FORCE TOTAL		**3,360**
e-Scrub - The Application of DNA Pulsed Power to Electron Scrubbing of Flue Gas to Remove Unwanted By-Products (DNA) #	53	6,000
DNA TOTAL		**6,000**
DoD TOTAL		**8,560**
TOTAL		**17,860**

Congressional Interest Program

PROJECT: INNOVATIVE TREATMENT OF CONTAMINATED GROUNDWATER AT MCCLELLAN AIR FORCE BASE (AFB), DAVIS, CALIFORNIA

OBJECTIVES: A combination of two innovative technologies is proposed to demonstrate the remediation of contaminated groundwater at the McClellan AFB site. The proposed demonstration will combine the groundwater withdrawal technology of horizontal wells with the treatment technology of pulsed ultraviolet (UV) to remediate the contaminated groundwater.

APPROACH: The Davis site is a radio-tracking station located in Davis, California, approximately 12 miles from Sacramento. The groundwater beneath the facility consists of multiple saturated layers, the first three of which are contaminated with low levels (50 to 500 ppb) of trichloroethane and tetrachloroethane. The contaminated units exhibit bidirectional groundwater flow based on local irrigation uses. This seasonal shift of flow direction impedes the migration of contamination from the site. These features underscore the suitability of the Davis site for this integrated technology demonstration.

The demonstration is planned to proceed in two steps to minimize cost and to optimize effectiveness. The first step will be a test of the treatment method using an existing reactor at the Davis site. The data from this test will provide implementation and design data for the full-scale treatment and withdrawal system. The second step will be installation of the horizontal well and the full-scale treatment of the contaminated groundwater. The Department of Energy (DOE) Office of Technology Development (OTD), will assist McClellan AFB with Strategic Environmental Research and Development Program (SERDP) funding to transfer the horizontal well technology from the DOE Savannah River Site to McClellan and cooperate in conducting the overall project.

BENEFITS: The withdrawal technology proposed for this demonstration is the use of horizontal withdrawal wells to remove contaminated groundwater from beneath the facility. The use of horizontal wells is favorable for the Davis site, given the plume geometry. Their use will also act as a technology transfer to the Air Force.

The pulsed UV treatment uses deep band UV light to effectively destroy chlorinated solvents and the daughter products of those solvents by destroying the chlorine bonds. This technology has shown substantial success in laboratory tests where pulsed UV treatment has achieved order-of-magnitude reductions of contaminants in groundwater in both batch and flow-through tests. Another version of this technology has been field tested at the Lawrence Livermore National Laboratory on a broad range of organic contaminants in high concentrations. This demonstration

will focus on low concentrations of solvents in groundwater using a more cost-effective, pulsed UV method.

PARTNERS AND RELATED ACTIVITIES: The DOE-OTD will cooperate with the Air Force in conducting the remediation demonstration. The horizontal well technology developed by DOE has been licensed to several private firms, and it is expected that the drilling will be accomplished with private industry involvement.

The information this demonstration is planned to be used in support of future Department of Energy and Department of Defense remediation efforts.

MILESTONES:

FY92 • Pilot treatment demonstration completed

FY93 Design and initiate procurement of horizontal well/pulsed UV treatment system.

FY93 Complete field demonstration.

FY94 Complete project report on demonstration and transfer system to full scale remediation.

FUNDING: FY 1992 $1.1M

ACTIVITY: Mr. Jerry Hyde
EM-551, Trevion II
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585-0002
Telephone: FTS 233-7914, Commercial: (301) 903-7914
Telefax: FTS 233-7234, Commercial: (301) 903-7914

Mr. J. Steele
Savannah River Laboratory
ISRL 773A, A208
Aiken, South Carolina 29802
Telephone: FTS 239-1830
Telefax: FTS 239-1660

Mr. Paul Carpenter
U.S. Air Force Engineering and Services Center
Environics Division (AFCESA/RAVW)
Tyndall AFB, Florida 32403
Telephone: DSN 523-6022, Commercial: (904) 283-6022
Telefax: DSN 523-6499, Commercial: (904) 283-6499

PROJECT: ENVIRONMENTALLY SAFE DISPOSAL OF EXPLOSIVE WASTES

OBJECTIVE: The purpose of this program is to develop and qualify environmentally safe processes for disposal of explosive wastes in the DOE Nuclear Weapons Complex (NWC). Arms control treaties and stockpile improvements are increasing explosive waste disposal requirements in the NWC and governmental regulations are precluding present means of disposal. In the program proposed here, candidate technologies for disposal of explosives will be investigated and recommendations will be made for promoting technologies by pilot plant operation.

APPROACH: This program is the first phase in the ultimate goal of developing a zero-waste system for high-explosives.

The Pantex plant operations will be seriously impacted by a lack of environmentally acceptable processes for the disposal of high explosives (HE) and related wastes from process streams. In the past, the U.S. has used open-pit burning for dry HE treatment and "ponding" for HE contaminated waste streams. Open-pit burning of HE, however, is being banned in several states and this ban may eventually extend to Texas, where Pantex is located. Also, states have begun to ban "ponding." The DOE has no alternative process for minimizing or destroying their HE waste in an environmentally acceptable manner.

Three distinct HE waste streams are generated at the Pantex Plant:

- large solid pieces generated from reject parts, mechanical property specimens, and stockpile-life test parts;
- contaminated rags, clothing, test equipment, etc.; and
- liquid waste from machining fluids, vacuum pump oil, formulation solvents, cleaning fluids, etc.

The DOE has two very important HE concerns that must be addressed immediately. An environmentally safe process for recycling HE from site returns and a total recycling capability for insensitive high explosives and for disposal of non-recyclable HE. The former task is near term, but the technology is being developed for the long term use as well. Most of the site returns for the next several years contain conventional plastic-bonded high-explosives (CPBX). The CPBX's have never been recycled in the U.S. Recycled CPBX, however, may have use in the DOD and possibly industry.

A single process probably will not be adequate for HE site return treatment. It probably will take a combination of three to five

different technologies. Several must be investigated because none is mature. Some of these include:

- recycling the CPBX;
- nonconventional machining to remove the CPBX from the pit--either water jet, oil jet, supercritical carbon dioxide, or solvent extraction;
- either closed loop incineration, plasma arc, or microwave treatment to destroy bulk explosives;
- treatment of slurries to destroy HE--supercritical water oxidation, subcritical media destruction, ultraviolet-light hydrogen-peroxide oxidation, pyrolysis, or molten salt oxidation;
- off-gas treatment using pyrolysis or pulsed plasma processing; and
- waste-water purification via filtration through activated charcoal, wier clarification, in combination with biodegradation.

Experts in each technology will evaluate emerging technologies. A peer-select panel will select the most promising technologies. Laboratory experiments in the selected technologies will be performed to validate parameters and establish requirements for the design and construction of pilot/demonstration process systems.

<u>BENEFITS:</u> The main benefit of this program is to provide alternative technologies for environmentally qualified and safe processes for disposal of high explosives waste in the DOE Nuclear Weapon Complex instead of open-pit outdoor burning. All of the technologies that DOE develops for its HE, either main charge or components containing internal HE, will be of use to DOD.

<u>PARTNERS AND RELATED ACTIVITIES:</u> In view of the mutual interest of the DOD and the DOE in the disposal of HE, we propose an equal cost sharing for this proposal. We welcome DOD participation in this activity. DOE proposes to use $1.8 million of DSRP funding for this activity, with the remaining $1.8 million funding from DOD.

<u>MILESTONES:</u>

FY92 Report recommending state-of-the-art HE disposal and recycling technologies for further development and establishing paramenters to be validated.

FY93 Complete the laboratory experimental investigation of the selected technologies for follow-on demonstrations directed toward production.

The funds for the pilot facility and/or demonstration facility will be from other sources.

<u>FUNDING:</u> FY 1992 $1.70M

<u>ACTIVITY:</u>

Howard R. Canter
Deputy Assistant Secretary for Complex Reconfiguration
U.S. Department of Energy, Washington, DC
FAX FTS 896-2180

Jack Swearengen
Supervisor, Technology Application
Sandia National Laboratories
Livermore, CA 94550
FTS 234-3022

James R. Humphrey
High Explosive Chemist
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550
Telephone: FTS 543-1844
FAX FTS 543-2164

PROJECT: RAPID SCREENING REVERSIBLE SENSOR FOR ENVIRONMENTAL SCREENING AND MONITORING

OBJECTIVE: To develop a reversible volatile organic compound (VOC) sensor for environmental screening and monitoring. The VOC outlined in this proposal would have several distinct technical advantages over existing technologies. Performance specifications include the following:

- Water and heat stable chemical sensor. Extends sensing potential to include hazardous environments. Extends sensing potential to include water sampling as well as vapor.

- Chemical sensor amenable to both remote and direct sampling configurations. Fiber optic configurations permit detection over great distances.

- Broad range of VOC's detectable. The sensing element is amenable to selective membrane configurations to impart selectivity capabilities if necessary.

- Potential for very low detection limits. Estimates of low part per million to upper part per billion detection capabilities expected for most VOC's.

- Simple sensor designs. Low cost devices. Estimates for various device configurations range from $500 per unit to as low as $30 per unit. Since the devices would be reusable in the field, the long term cost savings would be significant.

- Sensor would provide both instantaneous field detection data and a reusable field device.

Specific DOE sites targeted for immediate sensor applications to include the following:

- Waste Isolation Pilot Plant - drum screening and monitoring

- Vapor Vacuum Extraction Sites - site monitoring at INEL's RWMC facility and at the Savanna River site

- RWMC (INEL) - drum storage, soil, and groundwater monitoring

- Test Reactor Area) (INEL) - trichloroethylene groundwater monitoring

APPROACH: It is proposed to combine 3M Corporation's patented vapochromic double complex salt reagents with fiber optic technologies in the rapid development of a low cost, reusable

field sensor. The sensor will be configured to detect a broad range of VOC's, however, it will be calibrated for usage in field applications for the detection of selected analytes, e.g., carbon tetrachloride or trichloroethylene. Sensor development will be divided into five parts:

- synthesize several proprietary 3M vapochromic sensing elements
- full matrix laboratory evaluation of sensing elements
- sensor engineering design and construction of sensor prototype
- full matrix lab testing of prototype for a pre-determined analyte need
- field testing of prototype

The criteria for success will be the successful demonstration of sensor detection capabilities at one of the Arid Soils VOC's-Integrated Demonstration sites.

Preliminary laboratory work has demonstrated a high probability for success in the development of a sensitive and reversible VOC sensor for environmental screening and monitoring. The sensor will be stable to water and heat, provide instantaneous detection, and most importantly will be reusable in the field. It is of simple design but will provide rapid screening capabilities for pre-identified contaminants. The sensor will be configured to detect a broad range of VOC's, however, it will be calibrated for usage in field applications for the detection of carbon tetrachloride, trichloroethylene, or other selected analytes. Proprietary colorimetric inorganic reagents recently developed by 3M Corporation will be utilized in the development of the sensor. Successful engineering of 3M's vapochromic reagents with fiber optic technologies in the development of a first generation sensor prototype design has been demonstrated at the INEL. From this work, high probability is given for the rapid development of a low cost, reusable field sensor directly applicable to environmental characterization and monitoring.

<u>BENEFITS:</u> Successful development of this sensor technology would provide significant added capabilities to the area of remotely operated sensors capable of continuous and accurate monitoring of VOC's. Moreover, availability of sensitive, easy-to-operate field devices would enable real time analyses and reduce costs associated with collection and transport of samples to analytical laboratories.

<u>PARTNERS AND RELATED ACTIVITIES:</u> Successful development of this sensor technology would be enhanced through a collaboration with

3M Corporation. Future and immediate plans for this technology development include collaboration with 3M Corporation. Significant manpower and materials commitment has already been verbally communicated to the INEL by 3M management concerning a joint venture in sensor development.

As expected from disclosure in 3M Corporation's patent US4,826,774, rapid and reversible detection of numerous VOC's has been demonstrated using the INEL sensor device. Examples of VOC's readily detected through vapor sampling include: carbon tetrachloride, trichloroethylene, trichloroethanes, chloroform, methylene chloride, toluene, octanes, cyclohexane, ethanol, and acetone. This list is by no means comprehensive but exemplifies the potential to readily detect VOC vapors of a wide range of chemical compound classes.

MILESTONES:

FY	
92	Synthesis of vapochromic sensor material patented by 3M Corporation
92	Laboratory evaluation of vapochromic sensor material
92	Sensor engineering design and configuration
92	Laboratory testing of sensor device
93	Field testing and evaluation of sensor device
934	Vapochromic sensor material development, alternative sensor designs and configurations, field testing

FUNDING ($M):

FY92
0.5

CTIVITY: Dr. W. K. Reagen, INEL, (208) 526-7793
G. D. Lancaster, INEL (208) 526-1903
Fax (INEL): (208) 526-1390

PROJECT: DEVELOPMENT, EVALUATION AND APPLICATION OF BIOMARKERS FOR MUNITION EXPOSURE MONITORING

OBJECTIVES: More than thirty nitroaromatic compounds are produced as by-products during the manufacture of 2,4,6-trinitrotoluene (TNT). In addition to TNT itself, manufacturing wastes consist of a diverse mixture of nitrated toluene and benzene isomers, together with products of their reduction and photolysis. Contamination of aquatic and terrestrial environments by TNT and its congeners is known to occur in conjunction with plant discharges, spills, and the open burning of production wastes. Many, and perhaps most, of the major waste stream components have been shown to be toxic and/or mutagenic in a variety of test systems. As a producer and user of TNT, it is mandated that the U.S. Army assume responsibility for protecting human health and the environment from undue risks associated with TNT manufacturing practices and environmental contamination which has resulted from them. Research addressing improved and more sensitive methods and models for munitions related biological exposure and effects is necessary both for environmental monitoring purposes and the interpretation of biological response data. Toward that end, it is the objective of this research to establish a cost effective and workable experimental biological system which responds to the presence of TNT and associated munitions and to utilize this system for the development of exposure probes and to evaluate the applicability of those probes to munitions bioeffects monitoring.

BACKGROUND: Establishment of a Multipurpose Eukaryotic System for Probe Evaluation and the Study of Munitions—The use of animals as experimental and developmental systems for the study of xenobiotics is costly in terms of manpower, materials, and facilities. Likewise, the use of primary eukaryotic cells in culture requires animals or a source of their tissues and is labor intensive by virtue of the finite life span of such cells and the need for their repeated preparation. Continuous eukaryotic cell lines would appear to provide a workable solution to the problem, although most of them are either incapable of or possess a limited capacity for metabolic activation of chemicals. However, inducible phase I enzyme activity like that associated with cytochrome P-450 has been demonstrated in a few continuous cell lines following their immortalization, and both phase I and phase II conjugating enzymes have been demonstrated in several others. On such line, continuous rat hepatoma H4IIE cells, applied to munition bioeffects could provide the Army a cost effective system in developing biomarkers for its pollutants.

APPROACH: H4IIE cells are available commercially from the American Type Culture Collection, and testing of the stock has indicated that it possesses AHH activity after induction. Following the procurement of this cell line, it will be maintained and propagated at 37°C in a humidified 5% carbon dioxide atmosphere by means of standard tissue culture

techniques. Growth medium is that recommended by the supplier or Q-minimal essential medium without ribonucleosides and deoxyribonucleosides but with L-glutamine and supplemented with 10% each of fetal calf and calf serum and antibiotics. As an initial step in the work, it is proposed that the cytotoxicity of TNT, all major associated nitroaromatics, and the principal compounds (amines) that can be formed from them in the environment be determined in the cell system. A recent advance in cytotoxicity testing, neutral red uptake assays, provides a convenient means of miniaturizing and automating such analyses. The responsiveness and efficacy of the system for chemicals alone or in mixtures can be determined rapidly and inexpensively. Additionally, such studies can be conducted with and without pre-induction of the H4IIE cytochrome P-450 by potent planar hydrocarbon inducers at non-toxic levels to assess the effects of metabolic activation on munitions cytotoxicity. In itself, cytotoxicity can be considered as a biomarker, and a cell culture system that is responsive to the various TNT munitions or products of environmental reduction would be applicable to chemically contaminated soil/water samples in a context of clean-up and monitoring activities. Such a system would likely provide a less expensive alternative to current screening systems.

<u>BACKGROUND:</u> Probes for Biomonitoring—The development of molecular and biochemical probes for pollution biomonitoring is currently an active area of investigation. It is thought that such probes will be economical to apply, potentially applicable to biological specimens regardless of species of origin, and may signal changes in biological systems prior to observable macrobiotic effects. Thus studies are in progress to establish probes for susceptibility based on markers of responsiveness such as genetically determined target receptors and metabolic deficiencies, exposure based on the accumulation of chemicals and their bioreactive intermediates in biological fluids and macromolecules, and effects based on the induction of xenobiotic metabolizing systems and cellular damage and repair processes. As a long term goal in a context of xenobiotic insult, ideal probes would encompass all three areas: susceptibility, exposure, and effects.

For the most part, less complex systems such as induced xenobiotic metabolizing enzymes and adducted chemicals in macromolecules are being examined as exposure monitors; although they are not ideal in that they may not detect direct biological damage (genetic or otherwise), they can be inferred to do so in the light of the potential of chemicals formed or bound to cause adverse effects. Within such limits, interest exists today in the P-450 monooxygenase enzymes and antioxidant defense enzymes as inducible signal systems for xenobiotic chemical insult. The former systems have been the subject of considerable interest and much experimental effort; the latter have received far less attention but, by the nature of nitroaromatic metabolism itself,

could be even more appropriate for munitions pollutants. Conversely, a more complex and advanced approach based on genetic damage due to chemical insult has been recently proposed. In this approach, changes in selected genetic regions as markers of exposure are measured following their amplification in the laboratory by molecular methods. This approach has the advantage of measuring direct damage due to chemical exposure and may be applicable to sentinel species.

APPROACH: Cytochrome P-450 Probes—Cytochrome P-450 activity has been associated with the metabolism of nitroaromatic compounds and aromatic amines, as well as with the reduction of nitro groups. However, induction of the system(s) by nitroaromatics is both less clear and less well studied. Following their exposure to selected TNT associated nitroaromatic munitions, H4IIE cells will be screened for the induction of P-450 IA1 enzyme activities (aryl hydrocarbon hydroxylase and ethoxyresorufin hydroxylase). Should induction occur with these compounds, non-radioactive labeled molecular probes based on P-450 gene sequences will be developed and applied to the cell mRNA populations. Enzymatic activities versus molecular probes will be compared for their utility in biomonitoring. Should cytochrome P-450 probes appear to be appropriate for munitions based on *in vitro* studies, they could then be applied to exposed rats or rat sentinels at contaminated sites for validation.

BACKGROUND: Antioxidant Probes—The potential for cellular damage due to free radicals in biological systems is considerable. The metabolism of many xenobiotic compounds and particularly the nitroaromatics is known to generate oxygen free radicals, the most important being superoxide anion. To combat potential damage from superoxide anion when it is generated, subcellular defense systems have been evolved which include water soluble reductants (glutathione, ascorbate, urate), fat soluble vitamins (tocopherol, carotene), and enzymes (superoxide dismutase, catalase, and glutathione peroxidase). Superoxide dismutase (SOD) catalyzes the breakdown of superoxide anion to oxygen and hydrogen peroxide, itself a reactive intermediate. Peroxide is then removed by reaction with cellular catalase forming water and oxygen and with glutathione peroxidase in the presence of glutathione (GSH) forming oxidized glutathione (GSSG) and water. Because oxyradical generating compounds are likely a more diverse group than cytochrome P-450 inducers and because the generation of oxyradicals is closely related to quantifiable end points such as antioxidant enzyme activities, it has been suggested that these defenses may have considerable potential in serving a biomarkers for exposure to a wide range of pollutants.

APPROACH: To evaluate this concept, H4IIE cells will be exposed to key TNT related nitroaromatics *in vitro* and levels of SOD, catalase, and glutathione peroxidase will be determined and correlated with exposure. Should significant increases of any of the enzymes be noted, non-radioactive molecular probes for the

corresponding enzyme gene will be developed and used to analyze cell mRNA populations for increases following exposure. Depending on the results of cell culture exposure studies and degrees of molecular homology, enzymatic activities and nucleic acid probes will be evaluated as exposure monitors in rats or other species in the laboratory and/or in sentinels during validation studies.

BACKGROUND: Probes for Genetic Damage—Many of the munitions are mutagenic as well as toxic. A methodology has recently been developed and is currently being refined by which base changes, including point mutations, in short defined nucleic acid sequences can be determined. Essentially, sections of redundant genes (ribosomal RNA, transfer RNA, mitochondrial DNA) or selectable genes (hypoxanthine-guanine phosphoribosyl transferase, HGPRT) of known sequence in eukaryotic systems exposed to mutagens are amplified to high copy by polymerase chain reactions and purified. The sequences are then subjected to gel electrophoresis through denaturing gradients in which different base changes characteristically impede migration. Melting maps applied to the resulting electrophoretic profiles define points in the sequence at which mutation has occurred. The method has been used to assess the mutational spectra for chemical substances in lymphocytes selected on the bases of mutated HGPRT genes. For redundant cellular genes, it could be applicable to determining mutational frequency as well as spectrum.

APPROACH: The literature for defined sequences in selectable and redundant rat genes will be searched and candidate sequences identified. H4IIE cells will be exposed to known mutagenic TNT munitions. The selected sequences will be analyzed for the frequency of mutation and mutational spectra as appropriate. Mutations will be correlated with concentrations and times of exposure. Following establishment of the technology in vitro, it will be applied to experimental animals and extended to caged sentinels or reworked for application to natural species.

BENEFITS: This research will develop methodologies using biomarkers that will greatly enhance specificity and sensitivity in the detection of the presence of environmental contaminants. This will result in a greatly improved level of certainty and predictability in the assessment of the hazard of military contaminants.

PARTNERS AND RELATED ACTIVITIES: None. This research will be performed at the USABRDL laboratory facilities.

MILESTONES:

FY92 - Establish cell culture/munitions exposure in NR Uptake Assay. Complete cytotoxicity measurements for key munitions components in TNT wastewater. Screen for antioxidant enzymes

SOD, catalase, and GSH peroxidase following munitions exposure. Screen for P-450 induction after munitions exposure. Measure superoxide formation from munitions.

FY93 - Establish dose responses and antioxidant enzyme or P-450 induction. Develop nucleic acid probes based on enhanced P-450 or antioxidant enzymes. Establish mRNA isolation procedures. Identify rat genes for genetic studies. Complete superoxide measurements for munitions.

FY94 - Apply molecular probes to cells following munitions exposure. Establish technology for polymerase chain reactions and gradient gel electrophoresis. Evaluate munitions mutagenicity in the cell system.

FY95 - Validate probes in munitions exposed experimental animals. Identify candidate sentinel species based on molecular homology or field application. Establish mutational frequencies and spectra in munitions treated cells. Apply probes to sentinel species for validation.

FUNDING:

FY92	FY93	FY95
180	120K	120K

ACTIVITY: Dr. Wayne R. Mitchell, US Army BRDL, DSN 343-2538; 663-2538 for Munition Exposure Monitoring

PROJECT: DEVELOP MATHEMATICAL MODELS FOR SUBSURFACE FLOW AND CONTAMINANT TRANSPORT

OBJECTIVE: The objective is to refine and develop three-dimensional groundwater flow and contaminant transport modeling tools that will be coupled with digital characterization models. The contaminant transport and flow models must be general enough to allow simulation of the wide range of physical and biogeochemical processes which affect flow and contaminant transport/fate. The integrated models will assist in evaluating remediation alternatives, groundwater contamination, and cleanup optimization at DOD and DOE sites.

APPROACH: The contaminant transport code will consist of the 3D, time-varying mass transport (i.e., advection, diffusion, and mass sources/sinks) equation in the vadose and saturated zones. The model will be limited to dissolved organics and single-phase, single-component transport. The model will be written in modular fashion so it could be easily expanded to include trace metals and multicomponent transport. The code will be general enough to include all known phase transfer processes, such as sorption and volatilization, biogeochemical transformations, hydrolysis, oxidation-reduction reactions, biodegradation and biotransformation. The groundwater flow code will numerically integrate the three-dimensional, time-varying equations of mass and momentum in a coupled saturated-unsaturated zone framework. Spatial variability will be considered explicitly through incorporation of numerical algorithms depicting 3D subsurface hydraulic and soil type variation. The initial code will be developed for single-phase and rudimentary multiphase flow. More sophisticated multiphase flow simulation will be incorporated in later efforts. The model will be written in a specific modular fashion to allow for ease of update, and for coupling with a companion contaminant transport model in a comprehensive multi-dimensional groundwater modeling system. The flow and transport models will be coupled with digital characterization models and visualization/user interface tools developed under additional Environmental Quality research work units. Partnering with ongoing DOD, DOE, and EPA research will further extend the validity of the research products.

BENEFITS: Although a number of models exist that are capable, in some circumstances, of predicting groundwater movement, these models are often difficult to use, site-specific, or antiquated. The Army's ability to effectively predict the fate of contaminants within groundwater, and to appropriately manage the treatment of surface and groundwater resources, is directly linked to the accurate and efficient estimation of groundwater and contaminant movement. The proposed technology advancement will provide the ARMY and DOD with tools to more effectively predict the migration of organic contaminants in vadose and saturated zones. The ability to accurately model such migration behavior will allow evaluation of management and treatment

strategies proposed for use at contaminated sites. This capability will reduce the costs and time required for remedial alternative evaluations. The products of this research will provide the DOD with tools/models for the evaluation of remediation alternatives for many of its current contaminant concerns. The research also represents the foundation for future development of an integrated groundwater modeling system of enhanced sophistication.

PARTNERS AND RELATED ACTIVITIES: Partners include DOE, EPA, and States.

MILESTONES:	FY
Review and select existing approaches of coupled unsaturated/saturated single phase-single component groundwater flow and contaminant transport models. Initiate modification/development as appropriate	92
Develop knowledge-based system to support model selection in concert with Environmental Quality research	92
Develop mesh generation and visualization routines	93
Complete the initial version of the groundwater flow and contaminant transport models, implementing results from companion Environmental Quality research	93
Complete the coupling of the groundwater flow and transport models	93
Complete the initial verification and documentation of the groundwater contaminant transport model	94

FUNDING($K):	FY92	FY93	FY94	TOTAL
	720	900	800	2400

RESEARCH ACTIVITY: US Army Engineer Waterways Experiment Station, CEWES-HV-C (Dr. Jeffery P. Holland) 3909 Halls Ferry Rd. Vicksburg, MS.

PROJECT: ELIMINATION OF DU IN KE PENETRATORS

OBJECTIVES: To substitute non-radioactive tungsten alloys in place of radioactive depleted uranium (DU) in all major Army armament systems. The goal is to eliminate the environmental concerns that presently exist for maintaining a radioactive material (i.e., depleted uranium) in the Army material inventory.

APPROACH: New advances in material processing by rapid solidification technology will be implemented for the development of a new generation of tungsten alloys exhibiting ballistic performances matching those of radioactive depleted uranium alloys now being used by the Army in various armament systems. Presently, depleted uranium alloys are the materials of choice as kinetic energy penetrator cores because of their more effective terminal ballistic performance against a broad spectrum of target configurations. The most recent tungsten alloys developed under DOD/DARPA/DOE sponsorships still lack efficient terminal ballistic capabilities. These alloys have been fabricated using a traditional liquid phase sintering technology. This conventional processing technology is severely constrained in its ability to fabricate appropriate high density tungsten alloy in microstructures that exhibit beneficial ballistic penetration mechanisms. New processing technologies and manufacturing capabilities are therefore required to develop a new class of high density tungsten alloys that can re-establish the preeminence of these alloys for anti-armor kinetic energy penetrators.

A multi-disciplinary approach will be undertaken to accomplish the objectives of the program. Fundamental studies will be conducted at universities to clarify target-penetrator interactions so as to establish the beneficial microstructure that needs to be designed into tungsten heavy alloys for them to perform as efficiently as depleted uranium.

BENEFITS: A new tungsten alloy capable of displacing depleted uranium as the material of choice in armament systems will have a major impact on the environmental, logistic and life cycle burden the Army presently carries to maintain an effective warfighting capability. Conservative estimates for this yearly cost of doing business is $2M to $5M and growing as new DU items enter the inventory. Furthermore with tungsten there will no longer be environmental and disposal problems that presently exist in handling the present radioactive depleted uranium materials. In addition, a revitalization of the U.S. industrial base would occur with the introduction of tungsten as a major armament material. The potential for enhanced foreign military sales by our industrial base would become a major factor in not only lowering the unit cost burden of our ammunition supply but also providing for a reliable surge capability in times of national concern. The return on investment is therefore expected to be attractive and rapidly achieved.

PARTNERS AND RELATED ACTIVITIES: The U.S. Army has conducted various studies to assess the long term strategy for kinetic energy penetrator systems. In association with DARPA and DOE agencies joint research activities are being pursued to enhance the ballistic performance of these systems either through innovative system designs or material selections. Industry has been supportive of these efforts only when provided with federal funding since there is a limited commercial application for heavy metals. As such Cooperative R&D Agreements (CRDA's) are non-existent since the private sector sees little commercial utilization of high strength tungsten alloys aside from foreign military sales.

MILESTONES:

1. Develop unique precursor tungsten alloy powders	FY 91
2. Utilizing advanced powder consolidation system fabricate experimental lots of heavy alloys	FY 92
3. Assess ballistic performance of "designer" alloys	FY 93

FUNDING ($K):	FY 92
TOTAL	450

ACTIVITY: USA ARDEC, Dr. Shelton Cytron, Picatinny Arsenal, NJ 07806-5000

PROJECT: ELIMINATION OF CHLORINATED SOLVENT USE IN RED PHOSPHORUS (RP) MUNITIONS MANUFACTURE

OBJECTIVE: Pine Bluff Arsenal (PBA) has requirements to manufacture L8A3 RP Smoke Grenades at least through FY97. The RP-rubber smoke composition employed requires the use of methylene chloride in the manufacturing process and herein lies a major problem.

The recently enacted "Clean Air Act of 1990" requires the total elimination of the release of methylene chloride vapors to the atmosphere by the year 2000. This date may be advanced to 1995 in line with President Bush's initiative to stop production and use of ozone-depleting halogenated hydrocarbons. There is significant evidence that methylene chloride is one of the substances that poses a threat to the ozone layer. This would preclude the manufacture of the L8A3 grenade by the current process.

Furthermore, methylene chloride is regarded as a possible occupational carcinogen. For this reason the state of Arkansas, EPA and OSHA have directed that replacement solvents be identified. OSHA has proposed to reduce the 8-hour average human exposure limits from 500ppm to 25ppm. Compliance with this proposed regulation and other anticipated regulations and emission limits is becoming increasingly difficult and costly.

The objectives of this study will be to: (a) evaluate candidate replacement solvents, (b) develop a new RP/Butyl Rubber smoke mix process based on solvent selection, (c) conduct initial testing to verify that performance of L8A3 grenade with the new solvent is equivalent to or better than L8A3 grenades with methylene chloride, and (d) develop an implementation plan to include specification of required equipment/facility modifications for manufacture of L8A3 grenades with the new process.

APPROACH: Six candidate solvents have been identified by a literature search. These solvents will be evaluated by manufacturing L8A3 RP smoke compositions on a bench scale level. In addition to considering the solvents' properties, the effect on manufacture, performance, stability and storage life must be evaluated. After bench scale screening tests, a small lot of L8A3 grenades will be manufactured. Initial performance testing will be conducted. Results of this study to include an implementation plan will be documented in a Scientific and Technical Report. The implementation plan will be executed if elimination of methylene chloride is mandated by either the Clean Air Act of OSHA as anticipated.

BENEFITS: An implementation plan to eliminate the use of methylene chloride, a possible occupational carcinogen and ozone-depleting chemical, will be developed for the L8A3 grenade manufacturing process at PBA. This will assure lack of

interruption in the L8A3 procurement cycle due to adverse environmental impacts, and minimize manufacturing cost escalation as a result of new or tightened environmental regulations associated with the continued use of methylene chloride.

PARTNERS AND RELATED ACTIVITIES: PBA is the sole manufacturing facility in the United States for production of the L8A3 grenade. This study will be accomplished in its entirety at PBA.

MILESTONES

	Months After Funding Received	
	Start	Complete
Review candidate solvents		1
Prepare bench scale batches of RP composition using candidate solvents, evaluate manufacturing procedures, problems,	1	4
Develop new process	3	5
Load into grenades	5	6
Conduct initial performance testing	6	7
Prepare Scientific and Technical Report	6	9

FUNDING: ($K)

	FY92
In-house	80
OGA	150
TOTAL	230

ACTIVITY: USA, ARDEC, Picatinny Arsenal, NJ 07806-5000

PROJECT: ALTERNATE PROCESSES FOR LIQUID PROPELLANT MANUFACTURE

OBJECTIVE: The liquid propellant being developed for use with the AFAS consists of 80.8% Hydroxyl Ammonium Nitrate (HAN), 19.2% Triethanol Ammonium Nitrate and 20.0% water. HAN is produced as 2.8-3.5 molar product contaminated with residual nitric acid via an electrolytic process which requires the use of a liquid mercury cathode. The nitric acid is currently removed by passing this acid HAN over weak-base ion-exchange resins. There are environmental, safety and process issues associated with the use of resins for this purpose. Mercury is present in both as metallic and ionic forms. Metallic mercury is removed from the HAN via mercury traps. There is no method for removing ionic mercury from the product. The objectives of this program are to:

1. Identify techniques to reduce the level of ionic mercury in HAN to below detectable levels.

2. Demonstrate the feasibility of Electrochemically Facilitated Separation for the removal of nitric acid from 2.8-3.5 molar HAN without the use of resins.

APPROACH:

Mercury Removal

Perform a literature search to identify promising techniques such as resins with affinity for mercury. Select and test the performance of the best candidates in terms of product quality, environmental/safety implications and process economics. Issue findings in a Final Report. Develop demonstrated technology to support full-scale production of HAN, if feasible.

Electrochemically Facilitated Separation

Outline the objectives of the testing. These should include:

- Improvement of current efficiency (from 25% to more than 50%) through use of more selective anode side membranes.
- Improvement of HAN recovery through use of more selective cathode side membranes.
- Demonstration of membrane stability.
- Demonstration of electrode stability i.e., prove that there is no product contamination.
- Identification of optimal operating conditions; current, temperature and flowrates.
- Demonstration of control over a continuous process.
- Design a laboratory-scale cell from suitable materials.
- Define process to recycle the recovered weak nitric acid.
- Define economics of a production scale module.
- Perform preliminary hazards analysis to document improvements.

- Evaluate product quality, environmental/safety implications and process economics. Issue Final Report on findings.
- Develop demonstrated technology in support of full-scale production of HAN, if feasible.

BENEFITS:

Environmental

Mercury Removal Resins

- Mercury content of product will be reduced; possibly to below detectable limits. This will minimize the significant expense associated with handling, storage and disposal of mercury contaminated liquid propellant.

Electrochemically Facilitated Separation

- Does not require addition of chemical regenerant.
- Permits recovery/recycle of nitric acid.
- Eliminates disposal of solid resin which may be contaminated with mercury.
- Minimizes volume of waste significantly.

Safety:

Electrochemically Facilitated Separation

- Continuous operation minimizes amount of material present during operation
- Eliminates safety issues associated with drying-out of the resin bed.

Process:

Electrochemically Facilitated Separation

- Improves HAN recovery to 95% (over current 85%)
- Operates continuously; minimizes sizing.

PARTNERS AND RELATED ACTIVITIES: ARDEC, in conjunction with BRL, PBMA and Olin Corporation are in the process of demonstrating the performance of HAN pilot plant. SAChem produces commercially available HAN by a proprietary process (on a small scale). Thiokol Corporation blends HAN with other ingredients to produce liquid propellant.

MILESTONES:

	Months after contract award	
	Start	Complete
Literature search	0	1

Procurement/modification equipment/resin	1	
Pilot studies	4	11
Final Report	9	12

FUNDING: ($K)

	FY92
TOTAL	450

ACTIVITY: USA, ARDEC, Picatinny Arsenal, NJ 07806-5000

PROJECT: CADMIUM PLATING ALTERNATIVES

OBJECTIVE: Currently, 80% of the environmental releases of Cd may be directly related to electroplating waste. More than 50% of these discharges may be directly related to wastes generated by DOD Plating activities. Objective is to develop, evaluate and implement alternatives to Cd plate.

APPROACH: Select viable candidates, perform laboratory corrosion, adhesion, SCC, coefficient of friction, breakaway torques and compare results with Cd plate. Determine effects of co-mingling with Cd and galvanic coupling with steel and aluminum alloys.

BENEFITS: In addition to these environmental problems, Cd plating is a health hazard to workers operating electroplating baths. This project meets the DA goal of a 50% reduction in hazardous waste generation by 1995.

MILESTONES:

Sep 93	Laboratory testing of additional alternatives-Ion beam assisted deposition (Zn-Ni, AI-Zn)
Jul 94	Outdoor exposure tests
Jul 95	Field tests

FUNDING:

FY92	FY93	FY94	FY95
270	170	170	0

ACTIVITY: MTL, TACOM, OCR. Mr. Milton Levv- SLCMT-EMM, 617-923-5331

PROJECT: ENVIRONMENTALLY ACCEPTABLE METAL CLEANING

OBJECTIVE: This program addresses Army Environmental Management, specifically:

3. Pollution Prevention Pillar
II. Eliminate the need to purchase ozone-depleting substances by the end of 1995
3. Solvents
a. Non-ozone-depleting solvents for aircraft/weapons/shipboard/shoreside applications

APPROACH: The first year of Phase II will continue exploratory research (6.2) of potential cleaning replacements for ozone-depleting chemicals for different materials and their configurations. The second year of Phase II will implement (6.3a) previous findings and produce alternate cleaning procedures for DoD material that will be distributed to depots and other maintenance facilities.

BENEFIT: The Clean Air Act Amendments of 1990, DoDD 6059 and AMC Reg 70-68 require abolishing the use of halon and other ozone-depleting agents. The range of applicability includes all military ground vehicles.

MILESTONES: Phase II of the SBIR contract is currently unfunded. Clean Air Act Amendments of 1990 resulting in phaseout of CFCs and other ozone-depleting chemicals take effect in 1995. The end item will be a "cookbook" to environmentally acceptable cleaning processes for different materials and configurations. This "cookbook" will be delivered two years from the date of contract award.

UNFUNDED*

FUNDING:

Level of Effort	FY92	FY93	FY94	FY95
	230	220		

ACTIVITY: TACOM, Thomas M. Landy, AMSTA-UDM, (313) 574-8757 and Creare, Inc. (Hanover, NH).

PROJECT: INVESTIGATION OF AQUEOUS CLEANING SYSTEM TO REPLACE CFC VAPOR DEGREASER

OBJECTIVE: The manufacture of ammunition metal parts requires that specific components be degreased prior to subsequent industrial operations. Specifically, prior to painting large caliber projectile subassemblies, they are first vapor degreased using a CFC 113 based solvent to remove light water soluble cutting oils and hand oils. Increasing regulatory restrictions and the cost of CFC based solvents necessitate the implementation of alternative cleaning systems. DoD Directive 6050.9 and AMC-R 70-68 require that alternatives to CFCs be sought. The objective of this project is to adapt an aqueous based cleaning system for use in the large caliber projectile paint line.

APPROACH: Specifications for LAAPs cleaning system will be prepared and off-the-shelf equipment will be customized for the paint line.

BENEFIT: Substitution of CFC solvents will result in compliance with DoO and Army policy and the elimination of a portion of the Army's contribution to the concentrabon of stratospheric chlorine. Also eliminated will be the expense of the increasingly costly solvent and the generation of a listed hazardous waste. Continued reliance on CFC based solvents will adversely impact production when the production and importation of CFC based cleaning solvents is banned in 1995.

MILESTONES:

Dates	Completion
Select and validate cleaning agent and specify equipment	FY93
Prove-out equipment technology and install at LAAP	FY94

FUNDING ($K):

FY92	FY93	FY94
120	370	0

ACTIVITY: ARDEC, Mr. Mark Napolitano

PROJECT: REPLACEMENT OF CHLORINATED SOLVENTS IN ROCKET MOTOR PRIMERS AND TACKIFIERS

OBJECTIVE: Stickiness ("tack") is imparted to rubber to facilitate motor manufacturing: chlorinated solvent wipes are commonly employed for this purpose. Also state-of-the-art primers and adhesives are up to 90% alcohols. Process and material advances in paint and coatings science offer the potential for quick transfer to rocket motor manufacture.

APPROACH: An extensive literature, market and industry search will identify potential products which are either 100% non-volatile, water based or containing environmentally sound solvents. Major aerospace suppliers, such as Lord and Hysol, are developing adhesives and tackifiers of this type, and the commercial coatings industry offers many water-based, corrosion inhibiting primers. In the initial laboratory phase, the corrosion control of steel primers will be evaluated, and the bond strength of adhesives and tackifiers will be screened with two typical elastomeres on steel panels. From the screening study, the bond integrity of tow candidate will be tested in a typical propellant, insulation, substrate system at temperatures simulating the typical motor operating range (-65, 77 and +145°F). The best candidate system will be validated in a process sensitivity and accelerated aging program. The data and conclusions will be presented to the propulsion industry at the JANNAF Propulsion Meeting.

BENEFITS: Since essentially all solid propellant rocket motors employ primers, adhesives and tackifiers, the results of this program will be broadly applicable. Approximately 1,000 gallons of such solvents will be saved annually at this site and other small to medium rocket motor manufacturing operations, with savings up to 10,000 gallons annually at large operations (e.g., TITAN, Shuttle, Peacekeeper, Minuteman, Trident, Poseidon)

PARTNERS AND RELATED ACTIVITIES: Thiokol, Inc.

MILESTONES:

Screen 5-7 candidate for adhesion	FY92
Downselect to 2 candidate and verify bond system compatibility and adhesion	FY92
Complete 1 year aging of candidate mtls	FY93

FUNDING ($K)

FY 92	FY93
250	200

ACTIVITY: U.S. ARMY Missile Command, RSA, Diane Bowers, (205) 876-0887

TITLE: OIL SPILL TRANSPORT PREDICTION SYSTEM

OBJECTIVE: This project is designed to provide a first generation dynamic oil spill forecast capability. The Oil Spill Prediction System (OSPS) will combine existing and planned, state-of-the-art, ocean forecast systems with the best available oil spill model. The output of OSPS, applicable to both military and civilian needs, will provide real-time and near-real-time predictions of the transport, dispersion, and weathering of oil released in the oceanic environment.

APPROACH: The technical approach will include the design of an overall OSPS architecture to combine present state-of-the-art, real-time, modeling know-how with the best available oil spill forecast, science and technology. This will involve the assessment of all recent developments that have been attained at research institutions. The system will provide a capability to predict oil movement in open ocean, in coastal and semi-enclosed sea regions and in regions characterized by strong boundary currents. The tools for making operational predictions at regional centers and remote shore sites, as well as onboard ships will be developed. This oil spill prediction capability will be fully integrated with operational forecasting models using existing Cray YMP computers. The model(s) will be UNIX based and will therefore be operable on a wide range of computers. Some computers now being employed include: the HP-835, the SUN series systems and the Navy Tactical Environmental Support System (TESS(3)).

Existing dynamic models will be adapted to optimize the upper levels to provide appropriate response to wind forcing. In addition, a capability to assimilate in-situ and satellite data will be provided to assure real-time model updating. New or improved models will also be assessed for their applicability to the ocean regions discussed. Model(s) selected will be evaluated using available data sets and structured (prototyped) for operation on DoD operational systems.

BENEFITS: This program will benefit all federal agencies including the US Coast Guard. It will provide a unique capability for tracking and predicting oil movement in the event of accidental spills in peacetime. During conflicts, amphibious, and special warfare areas would receive direct support in the event of operational interference resulting from accidental or intentional oil release. The models developed through this effort will be designed to run on existing Navy mainframe operational supercomputers and on remote-site UNIX based transportable computers being used throughout the DOD Services (i.e.,SUN systems, HP-835, etc). In addition, the models will run on Navy Regional Oceanographic Center and shipboard computers. Oil spill prediction products would be available through any or all of these sources, i.e., central or remote sites. DOD has acknowledged Navy responsibility for ocean and atmospheric predictions. Cray YMP

supercomputers are being implemented at central sites, namely, the Fleet Numerical Oceanographic Center and the Naval Oceanographic Office to greatly improve DOD environmental prediction capability. Powerful small computers are being installed at Navy regional centers and on board ships for environmental prediction. Communication links being implemented by the Navy will provide an ability to send numerically generated data fields directly to these remote computers. In addition, the remote computers will have a capability to receive satellite generated images (IR, SAR and SSM/I) of the sea surface. The small computers (with communications capability) could be set up rapidly when needed by DOD activities or Joint Force Commanders at remote sites. All of the elements needed for real time ocean/atmospheric predictions will, as a result, be in place. This system will provide DOD and the US a unique global nowcast and forecast capability. An oil spill prediction model can and should be included within this prediction system. The model would provide a means for estimating: film breakup due to wave action, the loss of volatile components to the atmosphere, the dissipation of oil slicks due to wind action, and the prediction of oil impingement on beaches. It would also enable the identification and/or prediction of the oil film fringe location for the distribution of oil consuming microbes. DoD operates a large number of small craft and ships any one of which could be involved in oil spills. The location of an oil spill nowcast/ forecast capability within DOD will also directly support other US Government agencies responsible for civilian oil spills and oil spill cleanup. These include the National Oceanographic and Atmospheric Administration (NOAA), the US Coast Guard and the Environmental Protection Agency (EPA). The Minerals Management Service (MMS) would also benefit since they have a need for environmental statistics in connection with their offshore leasing programs.

PARTNERS AND RELATED ACTIVITIES: This development would be conducted with close cooperation with CNO OP-45 the Naval Facilities Engineering Command and the Naval Ship Engineering Command. We plan to work closely with the NOAA Hazardous Materials Response and Assessment Division, Seattle, Wash and the Army Corps of Engineer Research Center, Vickburg, MS. The work will also be closely coordinated with the Minerals Management Service.

MILESTONES:

- Develop improved Ekman wind drift formulation	FY92
- Evaluate deep/shallow water wind drift formulation	FY92
- Integrate Navy oil slick models with NOAA models.	FY 92/93
- Develop real-time capability for assimilating remotely sensed satellite and aircraft data into the integrated models.	FY92/93

FUNDING($M): FY 92: 0.30

POINT OF CONTACT: Robert A. Peloquin, Office of Naval Research, Arlington, VA 22217-5000, phone (703) 696-5084.

TITLE: NAVAL SHIP SYSTEMS RADIOLOGICAL CONTROL DETECTION

OBJECTIVE: Develop highly sensitive, accurate, user friendly, easily maintained, and cost effective systems for monitoring exposure to personnel while working with and around radiation sources on nuclear powered ships, in industrial and medical facilities, while recovering from nuclear accidents, and during environmental remediation of previously contaminated sites. The new systems will stem the spiraling servicing and calibration costs from obsolete instrumentation now in use. The new expandable technology will enable meeting continually more stringent federal accuracy and sensitivity criteria well into the future.

APPROACH: Major improvements are needed in the capabilities, calibration and repair of radiation survey meters and dosimeters. Current RADIAC instruments are 1940's vintage technology. They are single-purpose, insensitive, often contain radioactive material, and require frequent calibration. Maintenance costs continue to rise due to growing parts obsolescence and restrictions on shipping radioactive components. The first major improvement under development is the Multifunction RADIAC. It singly will replace up to 30 types of outdated radiacs, and will not be administratively hindered by containing any radioactive material. Its computer-based calibration and diagnostic system (ARCADES) will shorten by at least a factor of four the servicing/calibration time and expense, and be able to detect the smaller quantities of radiation recommended by cognizant scientific groups worldwide. The second major improvement is a new system under development for detecting and recording personnel radiation doses, the laser heated Thermoluminescent Dosimeter (LHTLD). This system will measure the low levels of radiation that a system must be able to measure to meet new NRC regulations and will provide sensitive measurements down to the levels required to meet all new and imminent health and safety requirements. It will accurately measure neutron radiation which the prevailing of the two current systems in use does not do. This is important because draft NRC regulations increase the hazard index associated with neutrons. It will replace the two older dosimetry systems currently in use with a less expensive, more reliable, simplified automated system. The automated system will save the Navy $600K per year at shipyards due to reduced manhours needed to read the dosimeters.

BENEFITS: The Multifunction RADIAC/ARCADES system will make radiation safety more affordable and readily available to all facets of nuclear Navy ships, site restoration, and the industrial and medical nuclear radiation programs. It will replace numerous single-use instruments. Benefits include high sensitivity, more rapid calibration, smaller required inventories, higher availability, easier transportability, and logistics savings. Savings of up to 75% of current RADIAC maintenance costs will start in 1996 and be fully realized by 2003. The technology

created in both these programs is expected to be fully commercialized in the 1992 to 1994 time frame. There are currently no known similar research and development programs underway in the civilian sector.

PARTNERS AND RELATED ACTIVITIES: The Defense Nuclear Agency is developing an alpha radiation probe to meet ANSI and NRC requirements. The probe will interface with the Multifunction RADIAC/ARCADE system. The Air Force is staffing a memorandum of agreement with the Navy in order to use the new systems to fulfill an established requirement under a Statement of Need (SON). They have been unable to obtain R&D funding for this type of system. A Joint Service Operational Requirement (JSOR) for the Multifunction RADIAC was issued by the Navy in April 1988. It is being staffed through the services. The laser heated TLD system will have widespread applicability throughout the other services, DOE, all other state and federal agencies with dosimetry needs, and the civilian community as a state-of-the-art dosimetry system.

MILESTONES: Milestone II, beginning of Engineering and Manufacturing Development, will occur in March 1992 for the Multifunction RADIAC System. Milestone III, production, will occur in September 1993. The laser heated TLD system began Engineering and Manufacturing Development in September 1990 and will reach Milestone III, production, in January 1994.

FUNDING: $M	FY 92
Multifunction RADIAC System	.10
Laser Heated TLD System	.40
Total	.50

Research Activity: U.S. Navy RADIAC Program (SEA 04R); Naval Sea Systems Command, Washington, DC. Phone: (703) 602-2753, AV 332-2753.
Sponsor: (OPNAV 455, phone (703) 602-2582, AV 332-2582.

PROJECT: LABORATORY AND FIELD MARINE BIOINDICATOR SYSTEMS

OBJECTIVE: Develop sensitive laboratory and field bioindicator systems that can be used simultaneously to evaluate contamination in the marine environment associated with Naval facilities, ships and operations.

APPROACH: The Navy has been required to document the extent of contamination and confirm the effectiveness of pollution control and cleanup operations in marine waters affected by the Navy. The most reliable measurement of impact (fate & effect) on the marine environment is the measure of the biological response in marine organisms. Current methods used for sampling and analysis do not make use of the accuracy, sensitivity and selectivity that can be achieved by emerging biological techniques.

Basic research in detection and recognition of chemicals by living organisms is necessary. This includes: characterizing molecular mechanisms and physical/chemical principles of detection of odorant chemicals by olfactory neurons and consequent signal transduction; identifying proteins and characterizing ligand receptor interactions, developing binding sites for target ligands through protein modeling and monoclonal antibody technology; synthesizing macrocyclic organic molecules having the ability to strongly bind heavy metals and whose spectroscopic indicators, e.g. fluorescence, are strongly modulated by metal binding; and developing neural network classifiers for pattern recognition in biosensor arrays.

Exploratory development is need in coupling response with measurement mechanisms using fiber optics, laser, fluorescent, spectroscopic and other techniques.

Advanced development of available bioassay procedures will be based on protocols utilizing a suite of invertebrate and vertebrate organisms known for their sensitivity to toxicants. Emphasis here will be on reliability, specificity, cost effectiveness and comparisons with standard protocol as well as selection of organisms appropriate to the receiving water matrix and reflective of receiving water conditions. Candidates include phytoplankton, amphipods, mysids, mussels, worms and fish. Protocols to be evaluated include life-cycle tests, embryo survival, larvae survival and growth and reproductive capacity. A variety of sublethal assays will be perfected including growth rate, bioaccumulation and phytoplankton measuring effects on fluorescence and bioluminescence light output. Assay and measurement developments will be supported by field measurements from a variety of platforms to confirm applicability.

BENEFITS: The limitations of existing protocols include lack of combined laboratory and field approaches, inadequate calibration of existing systems and inappropriate extrapolations to and from

real-world environments will be overcome. The resultant precision in measuring the effects of the Navy's presence on the marine environment will ensure against overregulation and misdirected or wasteful expenditures without useful environmental return and further assure that operations and compliance efforts provide for the protection and preservation of the marine resource required by the environmental policies of the United States.

PARTNERS & RELATED ACTIVITIES: Cooperative work on protocol development will be conducted between the Office of Naval Research, the Naval Research Laboratory Washington and Stennis Ms. EPA approval of developed methods will be pursued.

MILESTONES:

	FY
- Determine the most productive direction for environmental quality related biosensor research by furthering on going effort in diverse disciplines and collaboratively assimilating the state of the science for long term Navy approach.	93
- Complete field testing of in-situ mussel bioindicator system and develop standard operating procedures.	92
- Test and evaluation: EPA in-situ mysid chamber, NCCOSC field dosing apparatus, Transportable bioassay trailer, planktonic luminescence laboratory assay.	92
- Develop standard operating procedures for bioluminescence fluorescence, and ATP assay methodology.	93
- Simultaneous calibration of laboratory and field indicators, work with EPA on protocol acceptance.	93
- Finalize procedures and transition to compliance applications.	93

FUNDING ($M):

	FY 92
6.1	.1
6.2	.2
6.3	.3
Total:	.6

ACTIVITY: Office of the Chief of Naval Research POC Cdr Scott Sandgath (703) 696 4102. Naval Command Control and Ocean Surveillance Center (NRaD), San Diego, California, 92152 POC: P. F. Seligman (619) 553-2775.

PROJECT: SHIPBOARD SECONDARY AND TERTIARY BILGE WASTE TREATMENT SYSTEM

OBJECTIVE: Develop a shipboard secondary and tertiary bilge waste treatment system which will provide an effluent which meets existing and anticipated environmental regulations for overboard discharge of oil, heavy metals and other ultratrace contaminants.

APPROACH: Navy shipboard oil/water separators are designed to separate oil from water and produce and effluent which contains less than 20 parts per million oil. However, they do not meet the stringent effluent water quality requirements being imposed by the Clean Water Act and state, national and international regulations. These requirements place strict limitations on heavy metals and other EPA priority pollutants discharged into natural waters - even in ultratrace concentrations. By the year 2000, effluent quality requirements are expected to equal water quality requirements.

This project will result in shipboard equipment which will process bilge waste and provide an overboard discharge which meets existing and future requirements for all regulated constituents. The treatment system will be designed with inherent flexibility to accommodate the bilge generation levels, and thereby the bilge processing requirements, of all Navy ships.

Existing technologies for the treatment of bilge oily waste will be evaluated to provide a data base from which to select the best technology for meeting the particular and unique requirements of Navy shipboard equipment. In the absence of appropriate existing technology, state-of-the-art technologies/systems will be developed. The existing parallel-plate OWS technology on Navy ships is recognized as an excellent primary treatment stage. Therefore, emphasis will be placed on technologies and systems for secondary and tertiary treatment, as required. The most promising will be configured for affordability and shipboard use and, after preliminary testing in the laboratory, will be installed aboard a Navy surface ship for comprehensive TECHEVAL. Final system design, installation, and maintenance documentation will be prepared following a successful evaluation.

BENEFITS: The shipboard bilge waste treatment system will ensure that Navy ships meet all existing anticipated environmental requirements concerning the overboard discharge of all potential contaminants. The alternative, i.e., the inability of navy vessels to discharge "pollutant free" waste streams overboard, could potentially limit or even preclude the deployment of these vessels in territorial waters of the United States or foreign countries. Such limits on Naval operations are not acceptable.

The technology development and systems engineering necessary for the discharge of "environmentally sound" effluent from Navy ships can be transitioned for use aboard other Department of Defense ships and foreign naval vessels and by the domestic and international maritime industry as well. The overall positive effect is significant. The effects of heavy metals and other pollutants on the marine environment

are virulent, destroying marine organisms and, concurrently, the econor of the affected region.

PARTNERS AND RELATED ACTIVITIES: Navy, Naval Civil Engineering Laboratory, Port Hueneme, CA Technology developed and lessons learned in the Small Craft Bilge Treatment Systems program and in the development of a bilge waste treatment system for the Naval Weapons Station (NWS) Earl will be utilized and refined in this effort.

MILESTONES:

FY 92: Identify and select the most promising state-of-the-art technologies and systems for the secondary and tertiary treatment of shipboard bilge waste.

FY 92/93: Design and fabricate a shipboard secondary and tertiary bilge waste treatment system. Install aboard ship and evaluate.

FY 93: Complete shipboard evaluation and final design, installation and maintenance documentation.

FUNDING: $M

FY 92
.30

POINT OF CONTACT: Carderock Division, Naval Surface Warfare Center, Annapolis Detachment, Code 2834, Annapolis, MD 21402-5067. POC Mr. Craig Alig (410) 267-3526.

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FUNDING: $M

FY 92
.30

POINT OF CONTACT: Carderock Division, Naval Surface Warfare Center, Annapolis Detachment, Code 2834, Annapolis, MD 21402-5067. POC Mr. Craig Alig (410) 267-3526.

TITLE: NAVY SHIPBOARD HAZARDOUS MATERIALS REDUCTION

OBJECTIVES: Utilize and expand the Naval Surface Warfare Center Shipboard Hazardous Materials Database to identify hazardous materials used Navy-wide; reduce hazardous materials through consolidation, or substitution of less hazardous materials; and control the introduction of new hazardous materials into the Navy. Incorporate information on material substitution efforts into database, and provide database access to all military services so that substitution and minimization can be effectively implemented throughout the Department of Defense.

APPROACH: The diverse types and quantities of hazardous materials (HM) required by the Navy to achieve and maintain operational effectiveness have escalated thereby increasing the generation of hazardous waste (HW) and concomitantly raising the cost associated with HM/HW handling, storage and disposal. Successful reduction of hazardous materials used by the Navy demands a clear understanding of the requirements for hazardous materials to be on Navy ships or in use at shore activities. By employing the relational analysis capabilities of the Center's database, the technical requirements for hazardous materials can be assessed as either critical for general shipboard and shore maintenance.

The Navy HM feduction efforts includes collecting compositional information for products supplied under given NSN's, identifying target materials that require substitution, reviewing processes and applications, and performing risk assessments and economic analyses. Recommendations for material consolidation and substitution are made to equipment life cycle managers and inservice engineering agents for their technical evaluation and approval. Pertinent information on less hazardous substitutes and their applications will be incorporated into the database.

The success of this technology demonstration is certain because its approach is based on a completed lubricant reduction program for combat and weapon system equipment that resulted in a 64% overall reduction, (DTRC/SME-88/91).

BENEFITS: The reduction of Navy HM through an effective elimination and substitution program will reduce the costs associated with handling and storage of HM, and of its disposal as HW. Additionally, a reduction in the variety and quantities of HM will enhance the health and safety of all personnel, greatly facilitate the Navy's compliance with statutory requirements, and contribute significantly to preserving the environment. Project efforts will also be of immediate benefit to the Naval Supply Systems Command in their development and maintenance of a Navy-wide authorized HM use list. The NSWC database will serve as an information center for Navy-wide and service-wide substitution efforts.

The minization process and substitutes for hazardous materials can be applied to the industrial sector resulting in an overall reduction in the generation of industrial hazardous waste nation-wide.

PARTNERS AND RELATED ACTIVITIES: The Hazardous Materials Afloat Workir Group, under the leadership of the Naval Supply Systems Command, includes representives from the Atlantic and Pacific Fleets, the Echelc 2 Commands, the Navy Envioromental Health Center, the Naval Safety Center, and various shore communities, each committed to achieving the Navy's HM/HW reduction goals. Efforts to collect and share informatior pertaining to hazardous materials and hazardous waste Navy-wide are in progress. The U.S. Army and U.S. Air Force have also expressed an interest in participating in the hazardous material minization program.

Industry efforts to identify safe and effective substitutes for chlorinated solvents, especially the widely used CFC-113, and 1,1,1-trichloroethane solvents, and the U.S. Air Force's solvent substitutior program are being closely monitored. EPA reports on pollution prevention strategies including plans ro reduce 17 toxic chemicals by 50% by 1995 have also been given consideration.

MILESTONES:

Expand shipboard HM database to include all Navy used hazardous materials. Priortize HM for substitution, and utilize database to minimize or control highest priority HM. Sep 92

Incorporate into database information and status on substitution efforts Navy-wide, including material and process information. Sep 93

Provide database access to all military services to facilitate HM minization throughout DoD. Sep 93

FUNDING $M:

FY92
.30

ACTIVITY: Navy; Carderock Division, Naval Surface Warfare Center Annapolis Detachment, Code 2832
Annapolis, MD 21402-5067; (410) 267-3246
Laboratory Contact is Mr. Craig Alig, (410) 267-3526,

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FUNDING $M:

FY92
.30

ACTIVITY: Navy; Carderock Division, Naval Surface Warfare Center Annapolis Detachment, Code 2832
Annapolis, MD 21402-5067; (410) 267-3246
Laboratory Contact is Mr. Craig Alig, (410) 267-3526,

PROJECT: NAVY NON-OZONE DEPLETING TECHNOLOGY CLEARINGHOUSE

OBJECTIVE: Operate and maintain a centralized information collection, management/storage, and dissemination resource for new substances and technologies to replace uses of chemicals which are being restricted under the Montreal Protocol on Substances that deplete the Ozone Layer.

APPROACH: Collect and, upon request, inseminate technical data regarding potential substances and technologies for, and experience with, replacing CFC refrigerants and solvents and Halon firefighting agents. Information on chemical/physical properties, health and environmental effects, regulatory status, technology issues, and user experience with substitute chemicals and technologies will be collected, reviewed, and incorporated in a searchable database. Users of clearinghouse services will be encouraged to submit their own data and experiences when it becomes available.

BENEFITS: There are numerous applications for CFCs and Halons and many large and small users within the U.S. and foreign militaries and across ozone-depleting substances make it imperative that time and effort are not duplicated and wasted developing data and relearning lessons that can be readily obtained elsewhere. Widespread availability of technical data and operational experience with CFC/Halon substitutes will ensure that past successes and failures are considered by other suers attempting to elimanate their CFC/Halon uses. THE clearinghouse will reduce such duplication in R&D and testing and will permit more informed substitution decisions. It will also promote valuable interaction among users and suppliers, help identify common requirements/constraints which may better direct R&D efforts, and possibly facilitate the development of standards.

PARTNERS AND RELATED ACTIVITIES: Clearinghouse activities will be coordinated with related activities and capabilities within DoD, industry, and NATO allies.

MILESTONES:

FY92: Establish clearinghouse and begin operation internally within the Navy to assure performance and effectiveness.

FY92-FY93: Open Clearinghouse availablilty for Department of Defense and other government use.

FY93: General availability of Clearinghouse to industry and foreign users.

FUNDING: $M

FY92:

.20

POINTS OF CONTACT: U.S. Navy contact is Mr. Joel Krinsky, (703) 602-7599, Naval Sea Syst[illegible] 56Y1), Washington, D.C. 20362. Laboratory Contact is Mr. Craig Alig, (410) 267-3526, Carderock Division, Naval Surface [illegible] Center, Detachment Annapolis, Annapolis MD 21402-5067

POINTS OF CONTACT: U.S. Navy contact is Mr. Joel Krinsky, (703) 602-7599, Naval Sea Syst[illegible]EA 56Y1), Washington, D.C. 20362. Laboratory Contact is Mr. Craig Alig, (410) 267-3526, Carderock Division, Naval Surfac[illegible]ter, Detachment Annapolis, Annapolis MD 21402-5067

PROJECT: ORDNANCE USE/DISPOSAL RISK EVALUATION/MODELING

OBJECTIVE: Establish the capability to conduct air dispersion modeling for dispersion of airborne emissions from open burning/open detonation operations. The POLU10 will be used in conjunction with air dispersion modeling for the completion of risk assessments necessary in obtaining RCRA Subpart X permits for OB/OD.

APPROACH: Initially, the POLU10 combustion products program will be expanded to include a larger number of explosives/propellants/ pyrotechnics which may be treated by open burning/open detonation (OB/OD). The data from the POLU10 program will then be used as th input data for an OB/OD air dispersion model. The OB/OD air dispersion model will be developed specifically for the unique OB/OD operation. The developed model will be used to conduct the risk assessments which will be a portion of RCRA Subpart X (40CFR284.600) Part B, permitting for OB/OD activities.

BENEFITS: The project will benefit all DoD activities currently applying for Subpart X Part B developing a uniform means/method for determining the risk assessments.

PARTNERS AND RELATED ACTIVITIES: The project will be undertaken with assistance from Army activities and EPA personnel to ensure that the model meets regulatory requirements to conduct risk assessments for Subpart X permit submissions.

MILESTONES:	FY
- Expand POLU10	92
- Identify appropriate model	92
- Integrate POLU10/model	93
- Demonstrate model	93

FUNDING ($M):

FY92
0.10

POINT OF CONTACT: U.S. Navy, Naval Ordnance Station, Indian Head, M 20640-5000, POC: Pam Clements, Code OE, (301) 743-4450

PROJECT: CFC, HAZARDOUS AND TOXIC MATERIALS ELIMINATION

OBJECTIVE: The purpose of this program is to establish an enhanced in-house testing capability, and to test and evaluate new materials and processes which eliminate the use of hazaardous and toxic materials. CFCs will be phased out of existence as early as 1992 and other hazardous materials will follow suit in later years.

APPROACH: Potential substitute materials and processes will be evaluated via testing to the applicable requirements of the Air Force Logistic Command customers with the goal of qualifying the materials/processes for ALC use. The elimination of CFCs, will be investigated as will new processes and materials dealing with non-electrical metal/parts cleaning, adhesive bonding operations and painting operations. In order to gain any confidence in new materials/processes within a reasonable time period, some form of accelerated testing must be conducted in the laboratory to simulate actual service life. This is particularly true in the area of adhesive bonding and corrosive control. Part of this effort will be to develop better accelerated ageing test(s) stemming from the results of an AFLC-funded adhesive bond durability contract. In addition, in-house material processing capability will be upgraded where necessary and practical to ensure the ability to evaluate new materials and processes as well as run the proper controls for the testing. Such upgrade efforts will mainly focus on the preparation of parts for painting and bonding.

BENEFITS: New materials and processes that are environmentally compliant will become available to the given weapon system for incorporation with little or no compromise in performance parameters such as corrosion protection and adhesion. Also, improved equipment and test procedures will allow for more realistic testing of material and process substitutions. This program will assist efforts to provide an environmentally compliant system with comparable performance.

PARTNERS AND RELATED ACTIVITIES: Efforts will be coordinated and jointly funded as appropriate. Other substitute materials testing, including the use of CFCs for cleaning, will be conducted in the Materials Directorate for ALC or SPO customers. Toxicology testing of substitute materials will be conducted by Armstrong Laboratory.

MILESTONES:

Program Start	June 1992
Program Completion	June 1994

FUNDING ($K):

FY 92	FY 93	FY 94
450	700	500

ACTIVITY: WL/MLSE, J. Mazza, DSN 785-7483

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Program Start	June 1992
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FUNDING ($K):

FY 92	FY 93	FY 94
450	700	500

ACTIVITY: WL/MLSE, J. Mazza, DSN 785-7483

PROJECT: AEROSPACE SYSTEMS GUIDANCE AND CONTROL CFC ELIMINATION PROGRAM

OBJECTIVE: Aerospace systems guidance and control systems employ CFCs in literally thousands of different areas. The uses of CFCs in the build of systems guidance and control system has become essential in guaranteeing extreme levels of cleanliness for high reliability components.. In many areas the Air Force has mandated directly, in their drawings to use CFCs and no other substitute. Consequently, Air Force program Offices remain highly dependent on the use of CFCs and will be incapable of producing or maintaining highly reliable guidance systems in the future unless CFC replacement are developed. Due to the significant use of CFCs, the replacement will require detailed studies to validate the alternatives while not compromising the quality or accuracy of the guidance system.

APPROACH: The current CFC replacement program will build on initial research. This up front work selected a basic approach for solving the problem. The initial work identified a broad list of solvents and techniques with potential applications in the cleaning process. The continuing effort has been set up as a (3) phased program involving 3 contractors. The effort is expected to be completed by 30 JUN 94. Phase I will involve the identification of alternative solvents, test coupons and cleanliness criteria. The application process for the solvents above will also be investigated. Additionally, several other cleaning techniques will be investigated. They are: High Energy (plasma) cleaning, Carbon Dioxide Snow Cleaning and Super Critical Fluid Cleaning. This initial research will set the stage for phase II of the elimination program. Phase II will take the descoped solvent and technique lists and evaluate them for final down select. Multi-material piece part compatibility, and process application will be tested. Critical assemblies will be built using CFC-free processes and life tested. They will be tested then torn down to evaluate effects of new processes. Phase III will build on the results of Phase II. Assembly layouts will be modified and deviations initiated in order to build CFC-free instruments. Any program unique equipment needed to implement CFC-free assembly will be identified and installed. Guidance instruments will be built using CFC-free processes, then tested to ensure no detrimental effects at system level.

BENEFITS: The program is essential to supporting the designed capabilities of the fielded aerospace systems. Without CFC replacements the Air Force will be unable to repair failed guidance systems and still comply with the following: DODD 6050.9, AFR 19-15, which will prohibit USAF use of CFCs, the 1990 Clean Air Act, and the Montreal Protocol.

PARTNERS IN RELATED PROGRAMS: OC-ALC/LIIRN in conjunction with Aeronautical Systems Division (ASD) for application to aircraft gyros and instruments. Space Systems Division (SSD) for satellite applications. The Navy Trident Program (SP 234) is using this research to solve similar problems on their missile guidance and control systems. Coordination with the National Center for Manufacturing Sciences at 900 Victors Way, Ann Arbor, MI 48108-1779 will offer the opportunity benefit

from CFC substitute testing being accomplished by a manufacturing consortium.

MILESTONES:		
	10/30/92	PHASE I COMPLETE
	3/31/93	PHASE II COMPLETE

FUNDING ($K):

FY 92	FY 93	FY 94
500	1900	1400

ACTIVITY: HQ BMO/HVG, Capt George Rogers DSN 876-5695

PROJECT: RADIO FREQUENCY THERMAL HEATING OF SOIL TO REMOVE VOLATILE ORGANIC COMPOUNDS (VOCs)

OBJECTIVE: Develop, demonstrate, and optimize a pilot-scale (single module) and full scale (triple module) design to thermally remove VOCs commonly found in jet fuels and solvents from various soil matrices and depths in the vadose zone above the aquifer.

APPROACH: Tests are being conducted at shallow depths to demonstrate the VOC recovery efficiency of a single RF generator and vacuum extraction system from clay and sandy soils with various moisture contents in the range of 10 to 20 percent. In FY 85, pilot scale field demonstration tests were first conducted at Volk Field WI in sandy soil at depths up to 7 feet for 99 percentile removal of low boiling type VOCs found in jet fuels and cleaning solvents. A Kelly AFB TX field demo will target removal of similar tyupe VOCs at depths of 30 to 40 feet in clay soils of similar moisture content. By the end of FY 94, we hope to deliver a commercially available full-scale treatment system to Air Force users to achieve 99 percent removal of VOCs at shallow depths. Higher soil moisture contents and groundwater treatment to remove VOCs need further investigation.

BENEFIT: This in situ treatment method can provide tremendous savings as compared to excavation, incineration and landfill methods of contaminant removal. Heavily contaminated fuel spills can rapidly be cleaned up in a matter of weeks for volumes up to 3,000 cubic feet at low costs ranging from $40 to $75 per ton. RF technology can be used compatibly and complementary with other innovative technologies such as bioremediation and air stripping to achieve cleanup of even larger scale areas. RF technology has advantages over other technologies such as in-situ soil venting, bioventing, or biological treatment. RF cleanup on a volume-to-volume basis is faster and more efficient; bioremediation treatment can take months as compared to days for RF (12.5 days at Volk) and biological bacteria are not as effective in removing chlorinated hydrocarbons as RF. Excavation removal and incineration can cost $500 to $1000 per ton of soil treated.

PARTNERS AND RELATED ACTIVITIES: AFCEE, EPA, USATHAMA, and Army Corps of Engineers are sharing information related to this effort. The DOE Office of Technology Development is a strong advocate and is co-funding RF Technology Development to avoid duplication of efforts addressing similar VOC removal R&D. Tinker AFB and the DOE Savannah River are participating in Integrated Technology Demonstration planning activities with AFCESA. Private industry (General Electric, Westinghouse, O'Brien and Gere, etc.) is expressing strong interest in future design optimization activities on power generators and VOC vapor capture and treatment.

MILESTONES: FY 92 Kelly AFB Site 1 Single Module Demo Plan and Site Characterization Initiated; Pilot-Scale Treatment Starts.

FY 93 Site S-1 Demo Completed, Technical Report Submitted. Full-Scale Cleanup Plan using 3 RF Modules Initiated;

Technology Transfer to Kelly AFB and Users with Clay and Sandy Soil VOC Removal Requirements. Initiate deep soil demonstration in partnership with DOE Savannah River Lab and Tinker or McClellan AFB.

FY 94 Commercial availability of shallow soil applications in sandy and clay type soils at other AF bases.

FUNDING: Total Cost: $2000K

	FY 92	FY 93
($K)	860	1000

ACTIVITY: HQ AFCESA/RAVW, Paul R. Carpenter, DSN 523-6022

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ACTIVITY: HQ AFCESA/RAVW, Paul R. Carpenter, DSN 523-6022

PROJECT: MANUFACTURING TECHNOLOGY FOR LARGE AIRCRAFT ROBOTIC PAINT STRIPPING (LARPS)

OBJECTIVE: The prime objective of this program is to establish, for Oklahoma City Air Logistics Center (OC-ALC) implementation, an automated low-cost paint removal capability for large aircraft with minimal environmental impact. The program will establish an automated stripping process with the following characteristics: Reduced aircraft preparation, clean-up, and depaint manhours; reduced depot flow time; reduced ALC personnel exposure to the extremely hazardous work environment; lower cost; and a significant reduction of toxic/hazardous waste produced. Program requirements shall include a reduction of hazardous waste generation by 90%, and system availability of 85%, while maintaining surface quality acceptable in accordance with OC-ALC specific criteria. Program goals include reducing organic coating removal flow time by 50% over chemical stripping methods while reducing manhours by 50%.

BENEFITS: The LARPS system will cut OC-ALC paint removal costs by 57% annually according to a preliminary benefits analysis. More importantly, however, is the elimination of nearly 135,000 gallon/yr of hazardous methylene chloride based chemical strippers from aircraft paint removal operations. This accounts for 90% reduction in these potentially cancer causing chemicals. Oklahoma City Air Logistics Center currently spends $3 million per year to remove paint from C-135 series, B-52, B-1 and E-3 aircraft.

This program was awarded in July 1991 and is scheduled to be completed in June 1995. Due to the recent budget reductions in the MANTECH and AFLC, this program will be faced with reduced funding levels causing schedule delays and/or cancellation. It is imperative that this program be fully funded so that the environmental and technical benefits are realized. $900K is needed in FY92 to satisfy the immediate need.

FUNDING:

Appropriation	FY92	FY93	FY94	FY95
3600 ($K)	1425	1800	1324	50
3080 ($K)	1300	1300	1300	0
Funding Decrease	(400)	(200)		
SERDP	650			

ACTIVITY: WL/MTP, David See, DSN 785-3612

PROJECT: CHEMICAL TANK REJUVENATION

OBJECTIVE: The purpose of this program is the development of the necessary automated or in-situ filtration and conditioning systems(s) provide SA-ALC a completely installed, operational, chemical rejuvenation system. This system will reverse contamination and remov the sludge from the rust remover solutions Ferlon and Mil-C-14460, hydrochloric and nitric acid rust remover solutions, and rinse water solutions without removal of the tanks from service. The process will attempt to achieve near 100% chemical rejuvenation.

APPROACH: A needs analysis of system requirements for the rejuvenatio systems at SA-ALC will be made. The needs analysis will include a recommendation of the minimum hardware/software requirements or upgrad needed to satisfy the goals specified in this effort. An assessment o the technical capability and economic feasibility of the selected rejuvenation system(s) chosen will be made. This assessment will include an analysis and comparison of similar rejuvenation methods available or already in use within DOD and industry, their advantages, disadvantages, and limitations. The system will be designed to maximi the rejuvenation of the solution while minimizing the cost. The assessment will also address fixed vs. portable vs. in-situ rejuvenati systems. The full scale system will be fabricated, installed, and validated at SA-ALC. Full scale chemical rejuvenation tests of the solutions will be conducted. A training course will be offered on the explantaition and use of all aspects of the chemical rejuventation system. Documentation of operationg and maintenance procedures will l made. Level II drawings of all equipment parts which are specifically designed under this contract will be made and a parts which are specifically designed under this contract will be made and a parts and source list for all parts, including off-the-shelf parts will be made.

BENEFITS: Components to be cleaned or stripped are dipped in the appropriate solution, then rinsed with water and dried. This cycle leaves contaminated residue in the hydroxide and acid tanks, as well as in the rinse tank, causing degradation of the respective liquids thus requiring frequent fluid changes. SA-ALC has 3, 400 gallon and 13, 16 gallon rust remover tanks. They must be changed on a cycle ranging fr every 45 to 360 days. On average, 4-6 hours are required for each change. All 16 tanks have a companion rinse water tank which must als be changed. Since 95% of all components separated from gas turbine engines are subject to rust remover cleaner, reconditioning of the old rust remover solution will result in elimination of transportation and disposal of old solution. It will also reduce the need for purchase o new rust remover solution. The project could have wide spread applications, not only to the Air Force, but also DOD and the commercia aircraft industry as well.

Savings of over $600K/yr in new cleaning solution purchase costs alone can be realized by reconditioning the old solution.

PARTNERS AND RELATED ACTIVITIES: No activities in this area, to the best of our knowledge.

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PARTNERS AND RELATED ACTIVITIES: No activities in this area, to the best of our knowledge.

MILESTONES: Program start — Mid-FY 92
Program completion — Mid-FY 95

FUNDING ($K):

FY 92	FY 93	FY 94	FY 95	FY96
250	250	550	550	450

ACTIVITY: WL/MTP, S. Mazdiyasni, DSN 785-3612

PROJECT: ADVANCED MIXING TECHNOLOGY FOR LOW NOX GAS TURBINE COMBUSTOR

OBJECTIVE: Oxides of nitrogen (NOx) emissions from aircraft at high altitudes is estimated to be 30 times more harmful to the environment than ground emissions. NOx is the stratosphere depletes ozone and contributes to an increase in ultraviolet radiation reaching the earth surface. The International Civil Aviation Organization (ICAO) is on th verge of reducing the commercial aircraft NOx standard by 50%. A 90% reduction is expected by the year 2010. The Air Force is currently exempt from ICAO standards. However, Attachment 3 of Air Force Regulation 19-1, "Pollution Abatement and Environmental Quality," specifies goals for gaseous emissions for Air Force aircraft that are t ... "be periodically evaluated to insure support of national environmental objectives." Military engines operate much hotter than engines for commercial use in order to achieve higher levels of performance. NOx emission level is a strong function of peak operatin temperature. The performance trend in military propulsion is counter t the international pressure to reduce NOx. This program will develop fuel injection and mixing concepts for combustors that reduce NOx emissions in future Air Force engines while maintaining high performance.

APPROACH: Maintaining an optimal mixture of fuel and air everywhere within the combustor is critical in attaining very high performance levels while minimizing NOx formation. Wide excursions in the local fuel-air ratio, typical of current gas turbine engine combustor design, must be avoided. Fuel injection and fuel/air mixing processes that tak place in the primary flame zone of a combustor are key factors. This proposed program would leverage extensive resources already invested in an existing effort between the General Electric Company (GE) and the Aero Propulsion and Power Directorate (APPD) of Wright Laboratory. In the existing effort we are evaluating an advanced, dual-dome combustor design to develop technologies for maximum heat release, approaching stoichiometric combustion at the highest power settings. For maximum performance, controlling excursions in the local fuel-air ratio minimizes hot spots and pockets of inefficient combustion; for minimum NOx production, the approach reduces regions of molecular nitrogen dissociation, pockets of atomic nitrogen oxidation, and cold spots that freeze the products of undesirable reaction paths. For both the base program and the expanded effort which includes low Nox considerations, GE will provide the design expertise while APPD provides the testing ar instrumentation capability. Mixing effectiveness, specific oxides of nitrogen, and liquid and gas phase behavior will be measured non-intrusively with laser induced fluorescence, spectroscopic, and Mie scattering techniques, respectively. Resulting technology will enable designers to rationally trade between performance and low emissions, thereby addressing AFR 19-1 and enhancing the commercial competitivenes of the United States aviation engine industry.

MILESTONES:

12/93 Baseline: Measure mixing effectiveness and NOx within dual-dome combustor.

10/94 Prototype Injector/Mixer: Design and fabricate injector/mixer for low NOx.

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10/94 Prototype Injector/Mixer: Design and fabricate injector/mixer for low NOx.

9/95	Hardware Evaluation: Measure mixing effectiveness and NOx in prototype.
3/96	Modify Design: Optimize design for high performance and low NOx.
6/96	Evaluate Design: Measure performance and NOx in final hardware.
9/96	Trade-off Model: Document the procedure for trading performance and low emissions in the design of modern gas turbine combustors.

FUNDING ($K):

FY92	FY93	FY94	FY95	TOTAL
350	400	400	400	1550

ACTIVITY: Thomas A. Jackson, WL/POSF, DSN 785-6462

RESEARCH TITLE: Fiber Optic Monitoring System Development

OBJECTIVE: This project will develop fieldable prototypes of fiber optic monitoring systems from laboratory breadboard systems developed through previous Air Force projects. Fiber optic monitoring will allo in situ, real-time analysis.

APPROACH: Three related but independent research and development efforts will be undertaken: Transportable Laser Spectrometer (TLS), Attenuated Total Reflection (ATR) Fiber Optic Sensor, and Fiber Optic Electrochemilumenescence (ECL) Sensor. Spectroscopic analysis has bee well established within the laboratory and there have been several technological advances recently. This project provides for further development of the technology of transmitting light through optical fibers to a monitoring location and returning the resulting light. Th TLS effort has two objectives; the first is to is to simplify the syst for monitoring a specific contamination, e.g., benzene; the second is provide a versatile site investigation/monitoring system that could be used for qualitative and quantitative analysis of contaminants. The A Fiber Optic Sensor effort will be useful for monitoring both vapor and aqueous phase contaminants. This sensor could be supported by the TLS and will be useful for monitoring complex mixtures of contaminants. T Fiber Optic ECL Sensor does not require stimulation by an external lig source but still requires a spectrometer. It has the potential for being an inexpensive sensor for long-term site monitoring.

BENEFITS: Stringent groundwater monitoring requirements using traditional monitoring methods will place a tremendous burden upon Air Force resources because of costs and manning requirements. Air Force personnel will have new options and capabilities available for site investigations and monitoring. Significant cost savings will occur using fiber optic monitoring systems because of smaller, more easily installed monitoring points, reduced operation and maintenance costs, and decreased manning and technical expertise required. The knowledge furnished by improved characterization or monitoring of sites will afford better planned and conducted remedial activities.

PARTNERS IN RELATED ACTIVITIES: Research programs will be carried out at North Dakota State University, the University of Alabama in Huntsville, and by Cape Cod Research.

MILESTONES:

FY92: Base sensor and support system for intensive laboratory testing
FY93: Small-scale field demonstrations.

FUNDING ($K):

	FY92	FY93
AFCESA	300	600

RESEARCH ACTIVITY: AFCESA/RAVW, Bruce Nielsen, DSN 523-6011.

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FUNDING ($K):

	FY92	FY93
AFCESA	300	600

RESEARCH ACTIVITY: AFCESA/RAVW, Bruce Nielsen, DSN 523-6011.

RESEARCH TITLE: e SCRUB - The application of DNA pulsed power to electron scrubbing of flue gas to remove unwanted by-products.

OBJECTIVE: Utilizing electron beam dry scrubbing (EBDS), the objectives of this program are to demonstrate a cost effective approach for removing NO_x and air toxins from DoD incinerators and SO_2 and NO_2 from coal fired boilers. This program will also provide technology transfer so that civilian utilities which use high sulfur content coal can continue to do so and still comply with the Clean Air Act Amendment (CAAA) of 1990. Thus, this program will avoid the devasting economic impact of the CAAA on producers of high sulfur content coal.

APPROACH: The Defense Nuclear Agency has supported pulsed power research for nuclear weapons effects simulation (NWES) for many years. This research has presented DNA with an opportunity to integrate this electron beam technology into EBDS, to provide an affordable electron beam dry scrubbing of stack gases. Over the past twenty years, EBDS has demonstrated the efficient removal of SO_2 and NO_x from the stack gas of coal-fired facilities and NO_x and air toxins from the flue gas of incinerators. The DoD is mandated by the CAAA of 1990 to reduce emissions from its incinerators of NO_x and air toxins: these pollutants contribute significantly to the smog problems in urban areas. In addition, coal-fired facilities contribute significantly to acid rain and other air pollution problems through emission of SO_2 and NO_x. This problem is common to DoD coal fired facilities, and many commercial facilities. Furthermore, civilian utilities in the eastern United States which rely on high sulfur coal mined in the Appalachian area will also be severely affected by the CAAA 1990, which mandates significant reduction of both SO_2 and NO_x emission for existing plants and new construction.

Until now conventional electron beam generators have been too expensive for cost effective application of EBDS. However, in support of NWES, the Balanced Technology Initiative (BTI) and the Strategic Defense Initiative Office (SDIO), DNA has developed the high power transformer accelerator (HPTA), electron beam generator. This can satisfy the power, size and cost requirements for an EBDS process affordable by the utilities and Dod boilers burning high sulfur coal and incinerators burning municipal solid waste (MSW)

Specifically, using the HPTA technology, DNA will develop a high power, continuously pulsed electron beam generator; the major elements and support subsystems are:

(1) Slow power condition system, which includes main power supply, command resonance charge unit and thyratron switched unit;

(2) Saturable reactor modulator, which includes saturable reactor units, pulse forming lines, output lines, and reset circuits;

(3) High Power Transformer Accelerator which includes the cells, HPTA support structure, cathode stalk and its support structure;

(4) Electron Gun (E-Gun) which include thermionic-cathode support structure, thermionic cathode, grids, grid driver, foil and foil support structure;

(5) Instrumentation Command and Control (IC^2) which includes all diagnostics, safety interlocks and operation;

(6) Auxiliaries which include oil, water, and vacuum subsystems; heat exchangers; flowing gas load which includes duct-work, dryers and blowers; and facility modifications such as prime power, conduits, storage tanks and thermal management.

In addition, DNA will derive an optimum layout of an EBDS treatment facility utilizing HPTA for the electron gun.

<u>BENEFITS:</u> The DoD is mandated by the CAAA 1990 to significantly reduce the emissions of air toxins and NO_x from its incinerators, especially those within high smog urban zones or those that can effect these through air motion. A cost effective EBDS (made so through the application of DNA's HPTA electron beam generator technology) would simultaneously remove both of these pollutants. Furthermore, there is now a unique opportunity to transfer defense technologies conceived for use in SDI, BIT, and NWES to the civilian economy to address severe national environmental and economic concerns. With EBDS, a critical national environmental goal mandated by the CAAA 1990 can be met without a devastating economic impact on the coal industry and the users of high sulfur coal. The Defense Nuclear Agency believes that this transfer of defense technology is a very valuable addition to the overall Strategic Environmental Research and Development Program.

In addition, the advent of low cost gun technology will allow the cost effective application of e^-SCRUB up to 28 DoD coal fired facilities (in the range 10 to 45 MWe), removing ~95 percent of total SO_2 and $>$70 percent of total NO_x from each plant. This represents ~47 percent reduction of the total emissions by treating just 21 percent of the total (131) DoD coal fired facilities.

Finally, the development of a compact, high power, high efficiency, continuously-pulsed power system will facilitate a wide spectrum of advanced weapon system developments such as:

(1) Electronic jamming systems
(2) Electronic mine clearing devices
(3) Directed energy weapons such as high energy lasers and high power microwave sources

<u>PARTNERS AND RELATED ACTIVITIES:</u> The Defense Nuclear Agency will collaborate with the Karlsruhe Nuclear Research Center (KFK), which has an active program in the EBDS program with KFK. Karlsruhe Nuclear Research Center will apply the two-step irradiation process and moving gravel bed filter developed by KFK to the high sulfur content coal and moderate de-NO_x (70 to 80 percent removal efficiency) conditions appropriate to the East Coast of the United States. In addition they will apply the EBDS process to the high deNO_x and deSO_x, low deSO_x and high HCL levels typical of DoD incinerators burning municipal solid waste (MSP). The Defense Nuclear Agency will also collaborate with the

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University of West Virginia, which has an active program in the clean coal technology. They will assist in the analysis of EBDS for incinerators and utilities, along economic analysis of the by-product (fertilizer) value.

MILESTONES: During FY 92, DNA will perform an integrated test of these HPTA subsystems:

- Average Power	0.5 MW
- Run Time	10 Minutes
- Beam Kinetic Energy	800 keV
- Beam Current	6 kA
- Load	Flowing Gas

Also during FY 92, DNA will task KFK to document EBDS under conditions simulating high sulfur east coast coal and DoD incinerators burning municipal solid waste. Both the KFK II AGATE II Test Facility and kinetic reaction computer models will be applied.

FUNDING ($M):	FY 92
- SERDP	$6.0

RESEARCH ACTIVITY:

1. Office of Deputy Assistant Secretary of Defense for Environment, Room 206; 400 Army-Navy Drive; Arlington, Virginia 22202; Mr. James A. Marsh, (703) 695-8360

2. Defense Nuclear Agency, 6801 Telegraph Road; Alexandria, Virginia 22310; Major Jeffrey Cukr, (703) 325-0905

ENERGY

ENERGY		
	Phase II	
Technology Projects	**Page Number**	**FY 92 ($000)**
Photovoltaics (PV) for Military Applications	1	800
Geothermal Heat Pumps	3	400
Solar Thermal Dish/Stirling for DoD Applications	4	800
Windfarm for Military Installations (Additional Funding)	5	1,300
DOE TOTAL		**3,300**

PROJECT: PHOTOVOLTAICS (PV) FOR MILITARY APPLICATIONS

OBJECTIVE: (1) to identify near term high value opportunities for PV at military installations, (2) educate installation-level staff about the technical, economic, and environmental benefits of the technology.

APPROACH:

(1) Work with facility-level people to identify PV-project potential within their domain;

(2) Provide technical and economic expertise and support to develop specific projects at those installations with the greatest PV potential;

(3) Support R&D activities necessary to bring critical component technologies required to allow completion of high value applications, to the marketplace;

(4) Link DoD and PV industry participants in technology transfer and commercialization; and

(5) Provide broad-based training, technical assistance, and outreach support to prioritize coordinated efforts to assure optimum results from available limited resources.

BENEFITS: Benefits include environmental compliance, enhanced energy cost-savings and enhanced energy security. Today's PV systems have proven to be highly reliable. Select applications can also be implemented at competitive costs over their total life cycles. PV's zero emissions, low O&M costs, and domestic production are attributes which enable all these benefits to be realized. In addition, greater utilization of PV systems will enhance economies of scale on the production side, promoting further cost reductions--which will in turn expand the scope for greater PV utilization both in the military and civilian sectors (a SERDP objective).

PARTNERS AND RELATED ACTIVITIES: The principal partners involved in this effort are the DoD (specifically OSD and the PV Review Committee including the Office of Naval Research, the Air Force Civil Engineering and Services Agency, and the Army Corps of Engineers Construction Engineering Research Laboratory); the DOE (specifically the Office of Solar Energy Conversion and DOE labs such as Sandia, NREL, Oak Ridge and Lawrence Livermore Laboratories); and industry (SEIA). DOE/DoD collaboration in this area is already underway, together with a number of related outreach activities.

MILESTONES: This project will be completed by the end of FY 1992.

FUNDING: FY 92: $.9 million

POINT OF CONTACT: James E. Rannels, Director (202) 586-1720-Com'l
1000 Independence Avenue 896-1721-FTS
Washington, D.C. 20585 (202) 586-8134 FAX

PROJECT: GEOTHERMAL HEAT PUMPS

OBJECTIVE: Contribute to Department of Defense modernization and energy efficiency efforts by accelerating installation of geothermal heat pumps (GHPs) to reduce power consumption and maintenance costs at DOD facilities. Leverage DOD construction and retrofit funds with utility incentives and private sector shared savings contracts to save DOD $25-$50 million annually in electric power costs.

APPROACH: Install geothermal heat pump (GHP) systems in at least six DOD sites using SERDP funds to pay up to 100% of the incremental costs over traditional HVAC systems and fully fund a few residential.systems. Utilize the GHP ranking analysis and site specific preliminary design developed in the first SERDP phase to determine the initial installation sites. Assist DOD in completing design work, issue RFP, and manage installation. Monitor the GHP energy use and maintenance cost savings, compare with prior consumption, and provide results to DOD in negotiating future rate concessions from utilities based on peak load reductions from GHP installations. All GHP ground heat exchangers types will be considered. To maximize the number of installed sites the SERDP funds will be leveraged with utility financial incentives, shared savings contractors, and sites with major potential to continue GHP system expansion.

BENEFITS: Chapter 10 of Military Handbook 1190 states, "The most efficient method of using electric power for heating is the water source heat pump (GHP)..." Compared to air source heat pumps, GHPs reduce annual electric power consumption by 35%, electric peak loads up to 50%, refrigerant use by over 50%, and electric power plant emissions by 30%. Lifecycle costs for GHPs are excellent, often the lowest of all HVAC alternatives. With DOD spending $1.5 billion annually for electricity, a program retrofitting less efficient facilities with GHPs could save DOD $25-$50 million annually by the year 2000.

PARTNERS AND RELATED ACTIVITIES: A number of DOD sites, including the Patuxent Naval Air Station, Maryland; Camp Shelby, Mississippi; and Fort Polk, Louisiana have installed GHP systems to reduce energy costs, the need for new transmission lines, and utility demand charges. The private sector will pay for new GHP systems as part of a shared savings program and some utilities will provide incentives for installation of GHP systems to improve utility load balance. DOE and EPA are developing advanced programs to increase GHP use. The Farmers Home Administration uses GHP systems for low income housing, as GHPs offer the lowest life cycle cost.

MILESTONES: The project will be funded by the end of 1992.

FUNDING: FY 92: $.5 million

POINT OF CONTACT: Lew Pratsch, Geothermal Division, Conservation and Renewables, DOE (202) 586-1512

PROJECT: SOLAR THERMAL DISH/STIRLING FOR DOD APPLICATIONS

OBJECTIVE: Implementation of this proposal will establish the technology of using solar thermal dish/Stirling engine generation systems in the southwest for intermediate power. These plants could either be installed by a utility or an independent power producer at I facilities to provide power for military installations.

APPROACH: A 5 kWe dish/Stirling engine generation system is being developed by Cummins Power Generation Co. (CPGC) for remote applications. This is a joint venture proposal to field test units at user sites. The intention is to operate them under actual conditions power units to learn their operating, maintainence and reliability characteristics for remote sites. It is proposed that an additional unit be purchased for installation and operation at a military facilit to gain first-hand operational experience. A military installation would be a strong candidate for one of these plants when they are produced in production quantities, especially if the land were availak at a DOD facility.

BENEFITS: This effort would result in the military being able to have independent and secure power on their installations. The power generated from these units when mass produced should be competitively priced for peaking/intermediate remote applications. The installation would not require additional power lines to the facility to meet futur needs. Since land utilization for dish/Stirling systems is an importa factor, utilization of existing military bases for solar thermal powerplant parks could benefit DOD and the utilities.

PARTNERS AND RELATED ACTIVITIES: DOE and CPGC have entered into a joi venture project to produce three proof of concept test articles, three design verification units and then ten manufactured units, and to test them at user sites. To fabricate a new design verification or manufactured unit and to test it at a military site would cost about $900,000.

MILESTONES: A unit could be installed by late 1993 or 1994.

FUNDING: FY 1992 $.9M

POINT OF CONTACT: Gary D. Burch, (202) 586-0081

PROJECT: SOLAR THERMAL DISH/STIRLING FOR DOD APPLICATIONS

OBJECTIVE: Implementation of this proposal will establish the technology of using solar thermal dish/Stirling engine generation systems in the southwest for intermediate power. These plants could either be installed by a utility or an independent power producer at D(facilities to provide power for military installations.

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MILESTONES: A unit could be installed by late 1993 or 1994.

FUNDING: FY 1992 $.9M

POINT OF CONTACT: Gary D. Burch, (202) 586-0081

PROJECT: WINDFARM FOR MILITARY INSTALLATIONS (Additional Funding)

OBJECTIVE: The primary objective of this project is to demonstrate the cost and operational benefits of powering grid connected U.S. military facilities in high wind areas with state-of-the-art wind turbines.

APPROACH: Commercial wind turbines (windfarm of 1 MW or greater) will be purchased, adapted for military application at a selected location with a high wind resource, installed, and operated. In addition, DOD personnel will receive O&M training and participate in the development of test plans for the installation. The project will be managed by the National Renewable Energy Laboratory (NREL) with wind resource assessment and siting support from the Pacific Northwest Laboratory (PNL). NREL and PNL will work closely with the engineering staff of the selected DOD facility to develop procurement plans based on the facility's needs. Testing will be conducted for a period of at least one year.

BENEFITS: The primary benefit to the DOD facilities will be the reduced consumption of nonrenewable fossil fuels for electrical power generation. In addition to cost savings, the use of state-of-the-art wind turbines will result in an alternate energy source that will serve to increase base security by providing a backup power source and increasing reliability while decreasing the reliance on vulnerable primary power sources. Larger scale windfarms have the potential to save 100s of millions of dollars in reduced fuel and logistic costs over the lifetime of the wind turbines. There are several manufacturers of highly reliable wind systems now reporting greater than 95% availability with routine maintenance, and over 16,000 wind turbines currently installed in the U.S. providing about 1600 MW of bulk power to electric utilities. This project will serve to open related military applications.

PARTNERS AND RELATED ACTIVITIES: Similar work has been proposed for utility service areas in the Federal Wind Program and should be mutually beneficial. Partners in this work will include the wind energy industry, DOE National laboratories, and DOD (U.S. Army CERL).

MILESTONES: Project will be completed by the end of FY 1992.

FUNDING: FY 1992 - $1.4M (National laboratories/industry)

POINT OF CONTACT: Peter R. Goldman, Program Manager
Wind/Hydro/Ocean Division, (202) 586-1995

STRATEGIC ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM

INTERIM STATUS REPORT OF THE COUNCIL OCTOBER 1993

SERDP

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FOREWORD

The Strategic Environmental Research and Development Program (SERDP) is mandated in Title 10 U.S.C. §§2901-2904. SERDP addresses environmental matters of concern to the Department of Defense (DoD) and the Department of Energy (DOE). It is conducted as a tri-agency program with participation from the DoD, DOE and Environmental Protection Agency (EPA).

The SERDP identifies and develops technology to enhance capabilities to meet environmental commitments and to foster the exchange of scientific information and technologies among the participants, other governmental agencies and the private sector. The SERDP interacts with other environmental programs to identify and solve defense specific needs, extends applications of defense information to others, and builds on existing science and technology to derive more useable and cost effective approaches for achieving reductions in environmental risks.

The SERDP is managed by: a Council, which prescribes policies and procedures to implement the program; a Scientific Advisory Board, which advises the Council; and, an Executive Director and his staff, who handle the day-to-day management of the SERDP. The voting members of the SERDP Council are: the Director of Defense Research and Engineering; the Deputy Under Secretary of Defense for Environmental Security; the Vice Chairman of the Joint Chiefs of Staff; the Assistant Secretary of the Air Force, Space; the Assistant Secretary of Energy for Defense Programs; the Assistant Secretary of Energy for Environmental Restoration and Waste Management; the Director of the DOE Office of Energy Research; and, the Administrator of the EPA. Representatives from the Military Departments, the Coast Guard, and the Executive Director round out the Council as non-voting members. The list of members for the SERDP Scientific Advisory Board is shown in their annual report for FY 1992, which was submitted to Congress in April 1993.

This interim status report summarizes Phase I and Phase II projects, including data gathered through July 1993. It covers FY 1991 funding of \$69 million, FY 1992 funding of \$10 million, and \$69.8 million from the FY 1992 supplemental. SERDP funds remaining after the June 1992 rescission, \$69 M (FY 1991) and \$10 M (FY 1992), were distributed beginning in July 1992. After the required Scientific Advisory Board review, funds from the FY 1992 supplemental were allocated to performers from October 1992 through January 1993. In early July 1993, the SERDP Council approved the FY 1993 Strategic Investment Plan. FY 1993 funds for projects covered by this plan were released in September 1993, after the 30-day Congressional review had been completed. The details of the funding distribution for FY 1993 will be presented as a part of the FY 1994 Annual Report.

For the FY 1991/1992 program SERDP projects were grouped under four categories -- Remote Sensing, Installation Restoration and Waste Management, Energy, and Other, which included the Arctic Supercomputer project. Individual research projects were reviewed and

selected by the SERDP Council to fit an overall project funding target of $166 million. Approved projects were submitted to Congress on April 4, 1992 for its 30-day review. Projects which requested $1 million, or above, were reviewed by the SERDP Scientific Advisory Board (SAB) at meetings on June 11-12 and July 28-29, 1992.

ACRONYMS

ARPA	Advanced Research Projects Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRADA	Cooperative Research and Development Agreement
CWA	Clean Water Act
DDR&E	Director, Defense Research and Engineering
DOE	Department of Energy
DoD	Department of Defense
DSPO	Defense Support Program Office
EPA	Environmental Protection Agency
HAZMIN	Hazardous Waste Minimization
HW	Hazardous Waste
IR	Installation Restoration
IVD	Ion Vapor Deposition
LOVA	Low Vulnerability Ammunition
NASA	National Aeronautics and Space Administration
NRC	National Research Council
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NSF	National Science Foundation
OSD	Office of the Secretary of Defense
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
SAB	Scientific Advisory Board
SARA	Superfund Amendments and Reauthorization Act
S&T	Science and Technology
SERDP	Strategic Environmental Research and Development Program
SITE	Superfund Innovative Technology Evaluation
USDA	United States Department of Agriculture
USGCRP	U.S. Global Change Research Program
VOC	Volatile Organic Compound
WM	Waste Management

INTRODUCTION

This is an interim status report of the Strategic Research and Development Program (SERDP) Council. The report covers Phase I and Phase II projects and provides the current status of the program. Since the SERDP will be a part of the DoD budget submission starting in FY 1994, the first annual report, due March 1994, will report on the first year (FY 1994) of the five-year SERDP plan to be prepared by the SERDP Council during FY 1993 pursuant to 10 U.S.C. §2902(d)(3).

In April 1992 the Office of the Secretary of Defense (OSD) submitted the *SERDP Phase I Strategic Investment Plan, FY 1992* (hereafter designated as *Strategic Investment Plan I*) to Congress for its 30-day review. In July 1993 the *SERDP Phase II Strategic Investment Plan, FY 1992* (i.e., *Strategic Investment Plan II*) was sent to Congress. That submission was for the record, since the Appropriations Conference Report language accompanying the FY 1992 Supplemental Appropriation waived the need for the 30-day review of the Phase II program. OSD also submitted the *SERDP FY 1993 Strategic Investment Plan,* (i.e., *Strategic Investment Plan, FY 1993*) to Congress in early August 1993 for review.

The purpose of the SERDP is to address environmental matters of concern to the DoD and DOE. It is conducted as a tri-agency program with participation by DoD, DOE, and the EPA. The SERDP is intended to identify and develop technologies that will enhance the capability of DoD and DOE to meet their environmental commitments. In addition, it is intended to provide both technology and information that can be useful to governmental and private organizations in addressing environmental concerns. The SERDP interacts with other environmental programs to identify and contribute to the development of more effective and economical approaches to environmental problems.

This report describes the progress made to date as well as specific plans for the near term to address the goals of SERDP. The combined efforts of DoD, DOE, and EPA have been guided by the SERDP Council to assure that the SERDP is aggressively implemented. The efforts to date show there are opportunities for synergistically exploiting and transferring environmentally related technologies developed by the agencies to each other, and to other government and private organizations.

A Council decision on charging fees for information released in the SERDP program, as required by title 10 U.S.C. §2902(h)(a)(1), will be deferred until such time as the SERDP has begun to develop information suitable for transfer to the private sector.

The FY 1991/1992 SERDP projects reported here fall into the broad categories of Remote Sensing, Installation Restoration and Waste Management, and Energy. One specialized effort categorized as "Other" includes the Arctic Supercomputer.

PROGRAM SUMMARY

The SERDP efforts to date have emphasized the transfer of technology and data for the assessment of the state of the global atmospheric and ocean environments; the effectiveness of clean-up technologies for hazardous waste materials; the approaches to minimize, treat, and dispose of hazardous waste; methods for assessing hazards in existing and restored sites; and identifying and demonstrating clean energy and energy conservation projects.

Remote Sensing

Remote Sensing projects have focused on characterizing the global environment, using advanced technologies for detection, analysis, and evaluation. Advanced surveillance methods are being applied to oceanographic and land characterization. Archival data (both classified and unclassified from national assets) and new data will contribute to environmental modeling and analysis. Significant progress has been made in identifying data for public access that has been acquired and is under control of the Department of Defense. Data include the earth's radiation profile, tropospheric dynamics (chemistry, moisture, and temperature), and variation of trace constituents in the middle and upper atmosphere. Such data, which are critical to long-wave communications for military applications, also can be applied to predicting climatic changes.

Efforts were initiated to demonstrate the use of acoustics to monitor ocean temperatures, using technologies developed by the Navy and ARPA. This will provide an important tool to indicate global temperature change and will provide the basis for decisions on implementing a long-term acoustic measurement program.

Installation Restoration and Waste Management

Site cleanup and waste management are being addressed by demonstrating the most promising technologies, evaluating their effectiveness, and providing specific selection and design criteria to potential users. Reduction in costs and time for restoration are being sought as well. Pollution prevention efforts are focused on waste reduction, materials substitution, and process modifications. For remaining waste problems, such as hazardous organic and inorganic chemicals, efforts are directed toward characterization methods for soil and groundwater, as well as means to restore them to environmentally acceptable levels.

Energy

Demonstrations on alternative sources of energy and energy conservation means are directed at potential savings of $200 million a year in military installations. Funded projects consist of several alternative technologies that have direct application for immediate use in the Department of Defense complex and may have a considerable impact on the utilities industry.

Other Technology Projects

A grant was executed under which the University of Alaska shall serve as the owner, operator and administrator of the Arctic Region Supercomputing Center (ARSC). The ARSC shall serve the supercomputing needs of the SERDP and other DoD and national needs. The DoD will be entitled to 30 percent of the available CPU time at no additional charge.

The development of a reliable, cost-effective environmental management strategy for DoD sites is being pursued through the development of a scientifically defensible exposure-hazard-risk assessment methodology. This invaluable effort leverages the substantial investment made by EPA during its own Superfund Innovative Technology Evaluation (SITE) and assessment process and enhances this methodology for use by defense facilities.

In cooperation with the Office of the Secretary of Defense (OSD), EPA is preparing eight innovative technologies guidance manuals that provide potential permanent treatment options for contaminated waste sites at DoD installations.

Programs addressing DoD long term environmental R&D needs are being identified based upon user requirements and advancing technological capabilities for the development of a long term R&D strategy to guide the DoD into the next century.

ADDITIONAL TOPICAL REQUIREMENTS

Section 2902(h)(2) of title 10, United States Code, sets forth specific requirements which will be included in the first SERDP Annual Report. The information presented on the following pages provides an interim response to these requirements.

Section A. Actions to be taken during the five-year period covered by the plan to prevent duplication of research and development activities.

A1. Activities within DoD Elements

The Executive Director, SERDP, has worked closely with the Scientific Advisory Board, the SERDP Council and the multi-agency Working Group to develop a focused, well-coordinated program. Specific program execution, monitoring and reporting requirements will be implemented for the FY 1993 program. This is expected to facilitate the tracking and coordination of related efforts and ensure connectivity between Agencies. The principal coordinating mechanism within the Department of Defense remains within the guidance of Project Reliance.

Project Reliance's goal of eliminating duplication of Science and Technology activities and increasing the mutual reliance of the Services has been approached by analyzing the Services' Science and Technology programs, in particular, for the applicability of these programs to SERDP.

Project Reliance developed a conceptual framework to manage the transition from extensive, but informal cooperation to an increasing level of mutual reliance among the Services. The SERDP-related programs include technology areas in Environmental Quality (Oversight Responsibility: Joint Engineers), Environmental Science (Oversight Responsibility: Joint Directors of Laboratories - Environmental Sciences Panel), Medical (Oversight Responsibility: Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee), and Civil Engineering (Oversight Responsibility: Joint Engineers).

At the direction of Congress as stated in the Department of Defense Appropriation Bill, 1993, Report from the Committee on Appropriations, Senate Report 102-408, the Executive Director was tasked to certify that all efforts conducted with the additional funds provided to 6.1 (Basic Research) Environmental Quality Technology Programs within each Service, were not duplicating SERDP efforts. This has been accomplished.

Within DDR&E, tri-service reviews in such large areas as Environmental Quality, Environmental Sciences, Human Systems and Civil Engineering provide forums for surfacing

SERDP opportunities among the Services, while providing another mechanism to identify and eliminate duplicative efforts.

All of the services have mechanisms that track environmental programs. The Air Force has an Environmental Quality RD&A Strategic Plan, which employs a goal-oriented approach to review requirements and match them against the research underway and planned to assure optimum focus. An active, institutionalized effort conducted by the Army involves periodic reviews of its technology base programs in concert with the Army's user elements. Both the user and the developer are represented on the Army's Technology Base Advisory group and can assess ongoing research in terms of requirements and new opportunities.

The Army each year produces a Technology Base Master Plan, which makes public its goals in satisfying established requirements, as well as plans for exploiting emerging technologies in environmental concerns. The Air Force has an Environmental Inter-Laboratory Research Plan that captures all research in Environmental Quality, Safety, and Occupational Health. These efforts include an assessment and exploitation of research available in the private sector as well.

At the direction of the Deputy Chief of Naval Operations for Logistics, Navy user needs have been identified in a Technology Development Plan. This plan embraces seven broad areas addressing Ship, Shore, and Aircraft Facilities; Ordinance/Material Management; and Installation Restoration. The plan is routinely reviewed and updated by appropriate Chief of Naval Operations staff offices. The Assistant Secretary of the Navy for Installations and Environment has established a Navy/Marine Corps Environmental R&D Panel to facilitate science applications to compliance needs. The Office of Naval Research sponsors annual Science and Technology reviews in this area. The Navy is an active participant in several interservice coordination groups such as Joint Depot Environmental Panel.

A DoD report titled, <u>Tri-Service Environmental Quality R&D Strategic Plan</u>, prepared by the Tri-Service S&T Reliance Environmental Quality Panels based upon the Services' User Requirements, received its final review in June 1993. This report provides the cornerstone for DoD coordination efforts to eliminate duplication and ensure effective and efficient utilization of resources. Coordination within the DoD is carried out by the Tri-Service S&T Reliance panels in civil engineering and environmental quality under the Tri-Service Joint Engineers. Once coordination within the DoD environmental community is complete, the Long Term R&D Strategy will be expanded to develop technical exchanges in areas of mutual interest among the three major SERDP participants.

A2. Activities within Participating Agencies

A number of specific efforts have been developed to prevent duplication of research and development activities in the agencies (DoD, DOE, and EPA) participating in the program. Furthermore, effective lines of communication have been established between the participating agencies, NOAA, NASA and other government agencies, thereby reducing the likelihood of duplication.

The SERDP *Strategic Investment Plan I* emphasized many options for protecting, managing and restoring the environment. An executive action plan was developed from *Strategic Investment Plan I* to provide a more focused direction to SERDP. A vital part of this action plan was the establishment and implementation of a tri-agency Executive Working Group. One of its missions is to coordinate ongoing work to prevent duplication across the broad spectrum of environmental research and development, focus future efforts on promising options, encourage multi-agency technical cooperation in SERDP demonstration projects and recommend SERDP projects and plans to the SAB and SERDP Council.

At least one SERDP Program Review is planned to be held each year during an onsite visit by the Executive Director and appropriate program participants. The review will provide a technical forum for the exchange of ideas, discussion of investment strategy, program planning and execution and other management initiatives, plus the opportunity to openly establish programs which address common areas and mutually reinforce, rather than duplicate, each other.

Examples are presented below of actions presently underway in specific technical areas with DoD, EPA, DOE and others to coordinate and leverage existing activities relating to SERDP.

An interesting example of a multiagency (DoD, DOE and EPA) effort in Installation Restoration and Waste Management is the development of a site characterization and Analysis Penetrometer (SCAPS), a cone penetrometer system that can characterize hazardous waste site soils, perform a computer-assisted interpretation, and provide an on-site display of the results. This technology has potential for licensing under a Cooperative Research and Development Agreement (CRADA). Additional information on the cone penetrometer system is provided in **Section H**, p. 26, of this report.

The FY 1992 SERDP proposal, <u>Definition and Demonstration of Remote Sensing Capability to Contribute to Environmental Understanding and Support for Environmental Issues</u>, (pp. 3-5 of *Strategic Investment Plan I*), is a coordinated effort between DoD, EPA, and DOE. Topics addressed include establishment of data transfer and demonstrations related to the EPA's Environmental Monitoring and Assessment Program, DoD-Army's Integrated Training Area Management (ITAM) Program and DOE's Waste Site Assessment Activities. Another example of interagency coordination among SERDP participants is the FY 1992 SERDP project developed by DOE, <u>Photovoltaics for Military Applications</u>, (pp. 215-216 of *Strategic Investment Plan I*). The principal partners in this project are the DoD (OSD and the Photovoltaic Review Committee,

which includes the Office of Naval Research, the Air Force Engineering and Services Center and the U.S. Army Construction Engineering Research Laboratory) and the DOE (Office of Solar Energy Conversion and DOE's Sandia National, National Renewable Energy, Oak Ridge National and Lawrence Livermore National Laboratories). The DOE/DoD collaboration in this area is already underway, together with a number of outreach activities with industry.

The ARPA project, Acoustic Monitoring of Global Ocean Climate, (pp. 10-12 of *Strategic Investment Plan I*), combines several technical initiatives into a streamlined program involving multi-service, multi-agency and multi-lateral cooperation and coordination. ARPA will provide the overall program direction and will coordinate with military and civilian organizations, foreign governmental organizations, and research institutions. Coordination within DoD will be with the Navy and the Air Force, and within the U.S. Government with NOAA, NASA, DOE and NSF. At least nine foreign countries (Australia, Canada, France, India, Japan New Zealand, Norway, South Africa, and the USSR) have expressed an interest in participating in the acoustic monitoring program.

A number of DoD elements are involved with NASA in the development of the Earth Observing System (EOS) and on a larger scale, the Mission to Planet Earth (MPE) Program. While the systems involved in MPE will not be launched until the latter half of the 1990's, many of the SERDP efforts (such as those involved with global change) are apt to influence the design of experiments on EOS. A concerted effort will be made within SERDP to strengthen the bond with NASA and other Government agencies to insure that there is no unwarranted duplication of effort.

Section B. Involvement with Federal Interagency coordinating entities such as the Federal Coordinating Council of Science, Engineering, and Technology.

The U.S. Global Change Research Program (USGCRP) has been developed by the Committee on Earth and Environmental Sciences (CEES) of the Federal Coordinating Council of Science, Engineering, and Technology (FCCSET). *Strategic Investment Plan I*, (pp. 6-9 and pp. 10-12, respectively), contains two projects which directly relate to the USGCRP. These projects are:

Joint DoD and DOE Atmospheric Remote Sensing and Assessment Program for Global Climate Change, and Acoustic Monitoring of Global Ocean Climate.

The DoD representative to the FCCSET/CEES Subcommittee on Global Change Research is the Navy representative to the SERDP Council. This assures coupling with SERDP and the USGCRP.

The DoD representative to the FCCSET/CEES Subcommittee on Environmental Technology (SET) is the OSD staff officer for SERDP. This provides a direct coupling between SERDP and the SET.

EPA works through existing FCCSET mechanisms, e.g., the CEES, to coordinate its research and development activities in areas of major interest such as climate change.

DoD elements depend on organizations such as the National Research Council to obtain independent assessments that will guide future research. One example of this is the recently published report on Strategic Technologies for the Army (STAR). This report represents an independent evaluation of technologies that are apt to be of greatest importance to the Army in the years ahead, in terms of its military and infrastructure needs.

The National Research Council (NRC) has established a Commission on Life Sciences. Its Committee on Environmental Research was provided with details of the individual environmental research efforts currently underway in the DoD. Contact is also maintained between DoD and the Office of Management and Budget (OMB) and the Congressional Research Service (CRS).

Section C. Each project selected or recommended by the Council for support and funding, including the duration of, and the total estimated or (if known) actual cost of --

> **(i) each such project supported during the fiscal year in which the plan is submitted and the preceding fiscal year; and,**
>
> **(ii) each such project proposed for funding during the fiscal year in which the annual report is submitted and the following four fiscal years.**

Projects approved by the Council are described in *Strategic Investment Plans I & II*, including project duration and estimated cost. **Tables I - V**, pp. 9-16, show titles, executing organizations, and actual FY 1991/1992 funding received by projects described in *Strategic Investment Plan I.* **Tables I - V** also reflect the impact of the June 1992 rescission of funds and of the recommendations made by the SAB for those projects at or above $1 million. As of August 1, 1992 all funds identified as "actual" in **Tables I - V** under the FY 1991/1992 heading had been released to the executing organizations. Funds listed under the FY 1992 Supplemental heading were released from October 1992 through January 1993.

Tables VI - IX, pp. 16-19, show titles, executing organizations, and actual FY 1992 Supplemental appropriation funds received by SERDP Phase II projects approved by the SERDP Council. These projects are described in *Strategic Investment Plan I* and *Strategic Investment Plan II*. **Tables X - XII**, pp. 20-21, summarize project and participant funding totals.

The *Strategic Investment Plan, FY 1993*, which included titles, executing organizations, and funds planned for the support of FY 1993 SERDP projects, was submitted for Congressional review in early August 1993.

Starting in FY 1994, SERDP will become part of the DoD budget submission. The next annual report, due March 1994, will report on the first year (FY 1994) of the five-year SERDP plan and on the projects planned for the following four years.

TABLE I **REMOTE SENSING TECHNOLOGY PROJECTS - PHASE I**		**FY 1991/ 1992 $(000) Planned**	**FY 1991/ 1992 $(000) Actual**	**FY 1992 Supplemental $(000) Actual**
Definition and Demonstration of Remote Sensing Capability to Contribute to Environmental Understanding and Support for Environmental Issues	**DSPO**	8,600	0*	2,500**
Joint DoD and DOE Atmospheric Remote Sensing and Assessment Program for Global Climate Change	**NRL**	11,900	0*	5,000**
	DOE	23,500	0*	5,000**
Acoustic Monitoring of Global Ocean Climate	**ARPA**	20,000	0*	7,000**
* Rescission ** Congressional Interest	**REMOTE SENSING - PHASE I TOTAL**	**64,000**	**0***	**19,500****

TABLE II INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS - PHASE I		FY 1991/ 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
Basic Research and Development in Waste Management	DOE	4,200	3,047	1,153
Basic Research and Development in Environmental Restoration; New Insights on Natural Subsurface Heterogeneity	DOE	3,800	0	0
Plutonium and Uranium Metal Forming Technologies	DOE	6,100	5,500	600
DOE - PHASE I TOTAL		**14,100**	**8,547**	**1,753**
Develop and Demonstrate Effective Site Restoration, Pollution Prevention, and Pollution Control Technologies Applicable to Defense-Related Operations	EPA	9,700	6,533.6	4,547
EPA - PHASE I TOTAL		**9,700**	**6,533.6**	**4,547**
Composting of Explosives Contaminated Soil	Army	500	239	0
Nondestructive Decontamination of Chemical Agent Contaminated Structures	Army	3,500	1,675	0
Nondestructive Decontamination of Explosive/Propellant Contaminated Process Equipment	Army	300	144	0
Unexploded Ordnance (UXO) Detection	Army	1,100	526	0
Biomonitoring	Army	1,200	574	0
HAZMIN Technology for Tactical Vehicle Maintenance Operations	Army	1,000	250	750
Analytical Methods/Instrumentation Development	Army	1,200	574	0
Biomagnetic Separation Processes	Army	150	150	0
Use of Biomaterials for the Removal of Hazardous Chemicals for Contaminated Soils	Army	100	100	230
Waste Stream Cleanup by Enzymatic Oxidation in Non-Aqueous Solvents	Army	115	115	200
Enzymatic Decomposition of Energetic Materials	Army	290	290	0
Extraction & Recycling of LOVA Propellants Using Supercritical Fluids	Army	150	150	400
Fate & Transport in Seasonally Frozen Soil and Discontinuous Permafrost	Army	130	130	500
Identification and Testing of Non-Ozone Depleting Halon Agents	Army	125	125	300
Selective Recovery and Re-Use of Heavy Metals in Waste Streams with Bioengineered Polymers	Army	290	290	550
Effects of Sorption, Survival and Activity on Biological Treatment of Explosives and Organic Compounds	Army	250	250	500
ARMY - PHASE I TOTAL		**10,400**	**5,582**	**3,430**

TABLE II (Continued) **INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS - PHASE I**		FY 1991 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
In Situ Treatment of JP-5 and Fuel Oil Vapors in Unsaturated Soils	Navy	600	746	0
Underground Fuel Steam/Vacuum Removal	Navy	150	180	0
Small Arms Range Remediation	Navy	400	388	0
Heaped Soil Bioreactor	Navy	50	47	15
Underground Fuel Pump and Treat Demonstration	Navy	250	34	41
Coastal Area Capping Technology	Navy	200	91	167
PCB Decontamination Using Base Catalyzed Decomposition Processes (BCDP)	Navy	200	237	3
Fuel Contaminated Groundwater Treatment Using Photochemical Oxidation	Navy	45	28	23
Petroleum Contaminated Groundwater Treatment by Biological Processes	Navy	320	60	225
Slurry Bioreactors for HW Remediation	Navy	450	200	207
Penetrometer Transition/Validation	Navy	600	272	324
Penetrometer Chemical Sensors	Navy	430	267	122
Integrated Marine Risk Assessment Methodologies	Navy	570	353	303
Encapsulated or Immobilized Enzymes and Bacteria for Remediation of Fuel Spills	Navy	300	193	91
Buried Ordnance Detection	Navy	400	252	141
Mineralization of TNT to Innocuous End Products by Microorganisms	Navy	350	77	250
Chemical/Photochemical Processes for TNT/RDX Treatment	Navy	300	38	45
Biodegradation of Nitrate Esters	Navy	350	410	0
Characterization of Decomposition of Nitrate Esters	Navy	100	25	0
Range PEP Decontamination	Navy	150	0	0
Mobile Utility Support Equipment (MUSE) NOx Emissions Reduction	Navy	400	200	220
Leak Detection System for Large Underground Fuel Storage Tanks and Pipelines	Navy	500	156	353
Oxygen Breathing Apparatus Canister Disposal	Navy	145	391	6
Lithium Battery Disposal as Reactive Hazardous Waste	Navy	100	63	110
NAVY - PHASE I SUBTOTAL		**7,360**	**4,708**	**2,646**

TABLE II (Continued) **INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS - PHASE I**		**FY 1991/ 1992 $(000) Planned**	**FY 1991/ 1992 $(000) Actual**	**FY 1992 Supplemental $(000) Actual**
NAVY - PHASE I SUBTOTAL		**7,360**	**4,708**	**2,646**
Propellant Ingredient Extraction	**Navy**	100	156	0
Solventless Processing of Magnesium Teflon Viton (MTV) and Magnesium-Teflon Hytemp (MTH) Pyrotechnics	**Navy**	150	55	54
Explosive Waste as Fuel	**Navy**	100	250	60
Propellant Recycling	**Navy**	200	0	158
Ultraviolet Destruction of Nitrate Esters	**Navy**	300	170	192
Pyrotechnic Dye Incinerator	**Navy**	250	158	50
Bilge Waste Treatment System	**Navy**	400	672	158
Hazardous Material Shelflife Extension	**Navy**	200	71	60
Hazardous Material Control Technologies	**Navy**	400	236	71
Ship Paint Reformulation	**Navy**	500	315	185
Ship Abrasive Blast Recycling	**Navy**	560	0	288
Treatment of Waste Sodium Nitrite Solutions	**Navy**	120	66	0
Ship Surface Preparation and Paint Removal Technologies	**Navy**	250	50	200
Organic Protective Coatings and Application Technology	**Navy**	500	277	471
Non-Chlorinated Strippers and Low VOC Solvents	**Navy**	300	159	141
Aircraft Depainting Technology	**Navy**	500	29	93
Electroplating Waste Reduction	**Navy**	340	170	72
A/C Maintenance Chrome Replacement	**Navy**	200	160	28
IVD Aluminum	**Navy**	50	103	35
Aluminum-Manganese Electroplating from a Molten Salt Bath	**Navy**	100	35	103
HALON Replacement	**Navy**	120	120	0
Reduced Solids Precipitation Technology	**Navy**	100	75	0
NAVY - PHASE I TOTAL		**13,100**	**8,035**	**5,065**

TABLE II (Continued) **INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS - PHASE I**		**FY 1991/ 1992 $(000) Planned**	**FY 1991/ 1992 Actual Phase I**	**FY 1992 Supplemental Actual Phase I**
In-Situ Contaminant Mobility Reduction Using Surfactants	**Air Force**	105	105	0
Zero Discharge Plan Development	**Air Force**	500	500	0
Enhanced Anaerobic Degradation of Fuels in Groundwater	**Air Force**	200	200	0
Enhanced Redox Biodegradation	**Air Force**	400	400	163
Spray Casting as an Alternative for Electroplating	**Air Force**	650	650	0
Abiotic Degradation of Groundwater Contaminants	**Air Force**	160	78.2	0
Demonstration of Low Temperature Ashing for PMB Waste Treatment	**Air Force**	350	350	500
Toxicology	**Air Force**	1,000	1,000	0
Validation of Aphron Oxygen Enrichment of Subsurface	**Air Force**	300	0	60
Halon 1301 Aviation System Replacement	**Air Force**	300	555	0
Halon 1301 Facility Total Flood Agent Replacement Program	**Air Force**	400	448	0
Non-Toxic Surface Preparations for Aluminum and Titanium Structural Alloys	**Air Force**	100	100	**300
Crossflow Air Stripping with Catalytic Oxidation	**Air Force**	650	650	450
Minimal Treatment Option for JP-4 Contaminated Soil	**Air Force**	250	0	0
Alternative Solvents/Technologies for Paint Stripping	**Air Force**	300	250	905
Improved Hydrocarbon Remediation Monitoring	**Air Force**	400	0	400
Prototype VOC Monitor, Phase 3	**Air Force**	203	0	0
Pulsed Hydraulic Flushing	**Air Force**	300	300	0
Treatment of Chlorinated Organics with Above Ground Bioreactors	**Air Force**	400	381.8	305
Pilot-Scale Validation of Liquid Phase Oxidation	**Air Force**	300	200	0
Groundwater Transport in Model Systems	**Air Force**	80	164.8	0
Biodegradation Technology for Hazardous Waste Treatment	**Air Force**	200	0	0
Chemical Characterization of Carbonaceous Materials from Aquifers	**Air Force**	150	0	0
Advanced Microporous Membranes	**Air Force**	120	0	0
Spill Remediation Guide	**Air Force**	150	0	0
Demonstration of Soil Washing at Beale AFB with EPA (SITE Program)	**Air Force**	587	0	**50
** Phase II Funds	**AIR FORCE - PHASE I SUBTOTAL**	**8,555**	**6,332.8**	**2,783**

TABLE II (Continued) INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS PHASE I		FY 1991/ 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
AIR FORCE - PHASE I SUBTOTAL		**8,555**	**6,332.8**	**2,783**
Emerging Technologies with EPA - Support of SITE Program	**Air Force**	600	0	**286
Bioventing Demonstration with EPA	**Air Force**	175	148.2	247
Metabolic Pathways Control	**Air Force**	210	0	0
Anaerobic Dechlorination of C_1 and C_2 Organics	**Air Force**	50	0	0
Catalytic Destruction of Chlorinated Organics	**Air Force**	90	0	0
Fiber Optic Monitoring System Development (p. 18 also)	**Air Force**	190	0	191
Systems Integration for Monitoring Technologies	**Air Force**	250	437	0
Improved Methods for Monitoring Fuel Biodegradation	**Air Force**	400	35	0
Biodegradation of Energetic Materials	**Air Force**	130	0	0
Enhanced Biodegradation through Soil Venting	**Air Force**	450	0	0
Packed Tower Air Stripping	**Air Force**	150	0	0
In-Situ Biodegradation of Jet Fuels	**Air Force**	200	0	0
Electrolytic Reduction of Chlorinated Hydrocarbon Compounds	**Air Force**	50	0	0
--Phase II Projects Supported with Phase I Funds (Project titles are listed in Table VII, p. 18.)	**Air Force**	N.A.	N.A.	1,226
** Phase II Funds **AIR FORCE - PHASE I TOTAL**		**11,500**	**6,953**	**4,447**
DoD - PHASE I TOTAL		**35,000**	**20,570**	**12,942**
DOE - PHASE I TOTAL		**14,100**	**8,547**	**1,753**
EPA - PHASE I TOTAL		**9,700**	**6,533.6**	**4,547**
INSTALLATION RESTORATION AND WASTE MANAGEMENT - PHASE I TOTAL		**58,800**	**35,650.6**	**19,242**

TABLE III CLEAN ENERGY/CONSERVATION TECHNOLOGY PROJECTS PHASE I		FY 1991/ 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
Photovoltaics for Military Applications	DOE	4,000	4,000	0
Windfarm for Military Applications (p. 19 also)	DOE	1,500	1,500	0
Advanced Technology Assessment and Demonstration of Energy Efficient & Renewable Energy Technologies in DoD Facilities	DOE	2,300	0	2,300
Solar Detoxification of DoD Explosives in Soils	DOE	1,000	0	0
DOE - PHASE I TOTAL		**8,800**	**5,500**	**2,300**
Clean Energy/Conservation*	Army	2,700	2,504	196
* Under Installation Restoration in *Strategic Investment Plan I* **DoD - PHASE I TOTAL**		**2,700**	**2,504**	**196**
CLEAN ENERGY/CONSERVATION - PHASE I TOTAL		**11,500**	**8,004**	**2,496**

TABLE IV OTHER TECHNOLOGY PROJECTS PHASE I		FY 1991/ 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
Supercomputer Procurement, Installation, and Operation to Support the Arctic Region Supercomputing Center (ARSC) - University of Alaska	Army	*25,000	*25,000	0
Transfer of Information Related to Global Change Research - Consortium for International Earth Science Information Network (CIESIN)	DSPO	**1,200	*1,200	0
Supercomputing Support - National Supercomputing Center for Energy and the Environment (NSCEE) - University of Nevada, Las Vegas	Navy	***3,000	*3,000	0
Research to Characterize Environmental and Health Problems Associated with Defense-Related Operations	EPA	6,200	3,219.4	1,600
Development of Manuals of Practice on Innovative Technologies (DoD/EPA)	Army	250	250	0
Review of Environmental R&D Requirements, Identification of Functional Responsibilities, and Development of a Long Term R&D Strategy (DoD)	Army	250	0	0
DoD - PHASE I TOTAL		**29,700**	**29,450**	**0**
EPA - PHASE I TOTAL		**6,200**	**3,219.4**	**1,600**
OTHER - PHASE I TOTAL * Congressional Interest, ** Under Remote Sensing/DSPO in *Strategic Investment Plan I*, *** Under Remote Sensing/NRL in *Strategic Investment Plan I*		**35,900**	**32,669.4**	**1,600**

TABLE V FUNDING SUMMARY SERDP TECHNOLOGY PROJECTS PHASE I	FY 1991/ 1992 $(000) Planned	FY 1991/ 1992 $(000) Actual	FY 1992 Supplemental $(000) Actual
Remote Sensing	59,800	0	19,500
Installation Restoration and Waste Management	58,800	35,650.6	19,242
Clean Energy/Conservation	11,500	8,004	2,496
Other Technology Projects (Congressional Interests)	35,900	32,669.4	1,600
PROJECT TOTAL:	**166,000**	**76,324**	**42,838**
FY 1992 Sci. Advisory Board (SAB) and Council Support	1,500	550	381.25
*Expired, **FY 1993 SAB & Council Support, #Undist.	N.A.	*350	**1,000, #6.75
PROGRAM TOTAL	**167,500**	**77,224**	**44,226**
OSD Adjustments	N.A.	1,816	974
APPROPRIATION TOTAL (†69,040, FY 1991; 10,000, FY 1992)	N.A.	**†79,040**	**45,200**

TABLE VI REMOTE SENSING TECHNOLOGY PROJECTS PHASE II		FY 1992 Supplemental $(000) Planned	FY 1992 Supplemental $(000) Actual
Multispectral R&D for Environmental Analysis and Mapping	Army	400	390
Deep Permafrost Borehole Sites in Alaska	Army	450	439
Analysis of Submarine Acquired Ice Draft Data	Army	250	244
ARMY - PHASE II TOTAL		**1,100**	**1,073**
Numerical Sensitivity Studies for the Design of an Ocean Observing System	Navy	200	195
Instrumentation Development - Drifting Buoys	Navy	700	683
Marine Mammal Studies	Navy	300	292
Regional Time Series Surveys	Navy	300	293
Analysis of Submarine Acquired Ice Draft Data	Navy	100	98
DoD Global Change Research Program	Navy	100	98
NAVY - PHASE II TOTAL		**1,700**	**1,659**
Rem. Sensing, In-Situ, Lab Meas. for Assessment of Atm. Polln from USAF Ops.	Air Force	320	520
Atmospheric Radiance Algorithms for Global Remote Sensing	Air Force	320	320
AIR FORCE - PHASE II TOTAL		**640**	**840**
REMOTE SENSING - DoD - PHASE II TOTAL		**3,440**	**3,572**

TABLE VII **INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS PHASE II**		**FY 1992 Supplemental $(000) Planned**	**FY 1992 Supplemental $(000) Actual**
Innovative Treatment of Contaminated Groundwater at McClellan Air Force Base (AFB), Davis, California	**DOE**	1,100	1,200
Environmentally Safe Disposal of Explosive Wastes	**DOE**	1,700	1,800
Rapid Screening Reversible Sensor for Environmental Screening and Monitoring	**DOE**	500	700
DOE - PHASE II TOTAL		**3,300**	**3,700**
Development, Evaluation and Application of Biomarkers for Munition Exposure Monitoring	**Army**	180	176
Develop Mathematical Models for Subsurface Flow and Contaminant Transport	**Army**	720	703.5
Elimination of Depleted Uranium (DU) in Kinetic Energy (KE) Penetrators	**Army**	450	450
Elimination of Chlorinated Solvent Use in Red Phosphorus (RP) Munitions Manufacture	**Army**	230	230
Alternate Processes for Liquid Propellant Manufacture	**Army**	450	450
Cadmium Plating Alternatives	**Army**	270	270
Environmentally Acceptable Metal Cleaning	**Army**	230	0
Investigation of Aqueous Cleaning System to Replace CFC Vapor Degreaser	**Army**	120	120
Replacement for Chlorinated Solvents in Rocket Motor Primers & Tackifiers	**Army**	250	250
ARMY - PHASE II TOTAL		**2,900**	**2,649.5**

TABLE VII (Continued) **INSTALLATION RESTORATION AND WASTE MANAGEMENT TECHNOLOGY PROJECTS PHASE II**		FY 1992 Supplemental $(000) Planned	FY 1992 Supplemental $(000) Actual
Oil Spill Transport Prediction System	Navy	300	292
Naval Ship Systems Radiological Control Detection	Navy	500	488
Laboratory and Field Marine Bioindicator Systems	Navy	600	585
Shipboard Secondary and Tertiary Bilge Waste Treatment System	Navy	300	293
Navy Shipboard Hazardous Materials Reduction	Navy	300	293
Navy Non-Ozone Depleting Technology Clearinghouse	Navy	200	195
Ordnance Use/Disposal Risk Evaluation/Modeling	Navy	100	98
NAVY - PHASE II TOTAL		**2,300**	**2,244**
CFC, Hazardous and Toxic Materials Elimination	Air Force	450	450
Aerospace Systems Guidance and Control CRC Elimination Program	Air Force	500	**200 300
Radio Frequency Thermal Heating of Soil to Remove Volatile Organic Compounds	Air Force	860	**726 134
Manufacturing Technology for Large Aircraft Robotic Paint Stripping (LARPS)	Air Force	650	**300 350
Chemical Tank Rejuvenation	Air Force	250	250
Advanced Mixing Technology for Low NOx	Air Force	350	350
Fiber Optic Monitoring System Development (Additional funding)	Air Force	300	600
--Phase I Projects Supported with Phase II Funds (Project titles are listed in Table II, pp. 13-14)	Air Force	N.A.	636
** Phase I Funds **AIR FORCE - PHASE II TOTAL**		**3,360**	**3,070**
e~Scrub - The Application of DNA Pulsed Power to Electron Scrubbing of Flue Gas to Remove Unwanted By-Products *	DNA	6,000	6,000
* Congressional Interest **DNA - PHASE II TOTAL**		**6,000**	**6,000**
DoD - PHASE II TOTAL		**14,560**	**13,963.5**
DOE - PHASE II TOTAL		**3,300**	**3,700**
INSTALLATION AND WASTE MANAGEMENT - PHASE II TOTAL		**17,860**	**17,663.5**

TABLE VIII **CLEAN ENERGY/CONSERVATION TECHNOLOGY PROJECTS PHASE II**		**FY 1992 Supplemental $(000) Planned**	**FY 1992 Supplemental $(000) Actual**
Photovoltaics for Military Applications	**DOE**	800	0
Geothermal Heat Pumps	**DOE**	400	500
Solar Thermal Dish/Stirling for DoD Applications	**DOE**	800	900
Windfarm for Military Installations (Additional Funding)	**DOE**	1,300	1,385
DOE - CLEAN ENERGY/CONSERVATION - PHASE II TOTAL		**3,300**	**2,785**

TABLE IX **FUNDING SUMMARY SERDP TECHNOLOGY PROJECTS PHASE II**	**FY 1992 Supplemental $(000) Planned**	**FY 1992 Supplemental $(000) Actual**
Remote Sensing	3,440	3,572
Installation Restoration and Waste Management	17,860	17,663.5
Clean Energy/Conservation	3,300	2,785
PROJECT TOTAL	**24,600**	**24,020.5**
Scientific Advisory Board and Council Support	0	180
Undistributed	N.A.	1.5
PROGRAM TOTAL	**24,600**	**24,202**
OSD Adjustments	N.A.	398
APPROPRIATION TOTAL	N.A.	**24,600**

TABLE X FUNDING SUMMARY SERDP PROJECT TOTALS	FY 1991/ 1992 $(000) Phase I Actual	FY 1992 Supplemental $(000) Phase I Actual	FY 1992 Supplemental $(000) Phase II Actual	Program $(000) Totals
Remote Sensing	0	19,500	3,572	**23,072**
Installation Restoration and Waste Management	35,650.6	19,242	17,663.5	**72,556.1**
Clean Energy/Conservation	8,004	2,496	2,785	**13,285**
Other Technology Projects	32,669.4	1,600	0	**34,269.4**
PROJECT TOTAL	**76,324**	**42,838**	**24,020.5**	**143,182.5**
FY92 Sci. Adv. Brd. (SAB) & Council Support	550	381.25	180	**1,111.25**
*Expired,**FY93 SAB & Counc. Spt., #Undist.	*350	**1,000, #6.75	#1.5	**1,358.25**
PROGRAM TOTAL	**77,224**	**44,226**	**24,202**	**145,652**
Undistributed Congressional Adjustments	1,816	974	398	**3,188**
APPROPRIATION TOTAL	**79,040**	**45,200**	**24,600**	**148,840**

TABLE XI FUNDING SUMMARY SERDP PARTICIPANT TOTALS	FY 1991/ 1992 $(000) Phase I Actual	FY 1992 Supplemental $(000) Phase I Actual	FY 1992 Supplemental $(000) Phase II Actual	Program $(000) Totals
U.S. Army	33,336	3,626	3,722.5	**40,684.5**
U.S. Navy	11,035	10,065	3,903	**25,003**
U.S. Air Force	6,953	4,447	3,910	**15,310**
Defense Nuclear Agency (DNA)	0	0	6,000	**6,000**
Advanced Research Projects Agency (ARPA)	0	7,000	0	**7,000**
Defense Support Projects Office (DSPO)	1,200	2,500	0	**3,700**
U.S. Department of Defense (DoD) -- TOTAL	**52,524**	**27,638**	**17,535.5**	**97,697.5**
U.S. Department of Energy (DOE)	14,047	9,053	6,485	**29,585**
U.S. Environmental Protection Agency (EPA)	9,753	6,147	0	**15,900**
PROJECT TOTAL	**76,324**	**42,838**	**24,020.5**	**143,182.5**

TABLE XII FUNDING SUMMARY PROJECT & PARTICIPANT TOTALS $(000)	ARMY	NAVY	AIR FORCE	DNA	ARPA	DSPO	DOE	EPA	PROGRAM TOTAL
Remote Sensing	1,073	6,659	840	0	7,000	2,500	5,000	0	23,072
Installation Restoration and Waste Management	11,661.5	15,344	14,470	6,000	0	0	14,000	11,080.6	72,556.1
Clean Energy/ Conservation	2,700	0	0	0	0	0	10,585	0	13,285
Other Technology Projects	25,250	3,000	0	0	0	1,200	0	4,819.4	34,269.4
PROJECT TOTAL	40,684.5	25,003	15,310	6,000	7,000	3,700	29,585	15,900	143,182.5
FY 1992 Scientific Advisory Board and Council Support									1,111.25
FY 1993 Scientific Advisory Board and Council Support									1,000
Expired									350
Undistributed									8.25
PROGRAM TOTAL									145,652
Undistributed Congressional Adjustments									3,188
APPROPRIATION TOTAL (69,040 FY 1991; 79,800 FY 1992)									148,840

Section D. Amounts requested for SERDP for FY 1994.

Through a Program Budget Decision (PBD) the Deputy Secretary of Defense approved the inclusion of SERDP at $100 million in the Department's budget for FY 1994.

Section E. Amounts requested for FY 1994 for each Federal laboratory.

Amounts requested for FY 1994 for each Federal laboratory are expected to be available in January 1994 after the SERDP Council has approved the budget for the first year (FY 1994) of the five-year SERDP plan. These data will be included in the FY 1994 Annual Report.

Section F. Amounts made available for FY 1993 to each Federal laboratory.

Total amounts made available to each Federal laboratory from the FY 1991, FY 1992 and FY 1992-Supplemental Appropriations are shown in **Table XIII**, pp. 23-25.

Amounts to be made available to each Federal laboratory for FY 1993 will be known after the Congressional review of the FY 1993 program during August 1993. These data will be covered in the FY 1994 Annual Report.

TABLE XIII **LABORATORY FUNDING FROM THE FY 1991, FY 1992 & FY 1992-SUPPLEMENTAL APPROPRIATIONS**	**Total Funds $(000)**
U.S. ARMY	
Army Environmental Center, Aberdeen Proving Ground, MD	3,732
Biomedical Research and Development Laboratory, Fort Dietrick, MD	176
Construction Engineering Research Laboratory, Champaign, IL	2,700
Chemical Research, Development, & Eng. Center, Aberdeen Proving Ground, MD	795
Armament Engineering Directorate, Picatinny Arsenal, NJ	2,540
Army Research Laboratory, Aberdeen Proving Ground & Adelphi, MD	975
Cold Regions Research & Engineering Laboratory, Hanover, NH	1,313
Missile Command, Redstone Arsenal, Huntsville, AL	250
Natick Research, Development, & Engineering Center, Natick, MA	840
Tank Automotive Command - Research, Development, & Eng. Center, Detroit, MI	270
Topographic Engineering Center, Ft. Belvoir, VA	390
Waterways Experiment Station, Vicksburg, MI	1,453.5
U.S. ARMY TOTAL	**15,434.5**
U.S. NAVY	
ONR, Arlington, VA	1,268
NCEL, Port Hueneme, CA	4,535
NCCOSC, San Diego, CA	2,633
NSWC, Indian Head, MD	2,009
NAWC, Warminster, PA	1,512
NSWC, Carderock/Annapolis, MD	1,954
NRL, Washington, DC	6,482
NAVSEA (Code 5141), Washington, DC	1,183
Navy Com and Telecomm Sta, Norfolk, VA	232
NAWC, Lakehurst, NC	120
Portsmouth Naval Shipyard, Portsmouth, NH	75
U.S. NAVY TOTAL	**22,003**

TABLE XIII (Continued) **LABORATORY FUNDING FROM THE FY 1991, FY 1992 & FY 1992-SUPPLEMENTAL APPROPRIATIONS**	**Total Funds $(000)**
U.S. AIR FORCE	
Tyndall Air Force Base, FL	9,752
Wright Patterson Air Force Base, OH	2,655
Brooks Air Force Base, TX	1,563
Hanscom Air Force Base, MA	840
Norton Air Force Base, CA	500
U.S. AIR FORCE TOTAL	**15,310**
U.S. DEPARTMENT OF DEFENSE TOTAL	**52,747.5**
U.S. DEPARTMENT OF ENERGY	
Los Alamos Laboratories, NM	3,075
Lawrence Livermore Laboratory, CA	3,900
Oak Ridge National Laboratory, TN	2,290
Oak Ridge National Laboratory/Y-12, TN	500
Sandia National Laboratory, NM	10,250
Pacific Northwest Laboratory, WA	1,425
Argonne National Laboratories, IL	860
Idaho National Engineering Laboratory, ID	700
National Renewable Energy Laboratory, CO	6,585
U.S. DEPARTMENT OF ENERGY TOTAL	**29,585**
U.S. ENVIRONMENTAL PROTECTION AGENCY	
Environmental Monitoring Systems Laboratory, Cincinnati, OH	504
Atmospheric Research & Exposure Assessment Lab, Research Triangle Park, NC	200
Environmental Research Laboratory, Athens, GA	4,359.2
Environmental Research Laboratory, Corvallis, OR	405

TABLE XIII (Continued) **LABORATORY FUNDING FROM THE FY 1991, FY 1992 & FY 1992-SUPPLEMENTAL APPROPRIATIONS**	**Total Funds $(000)**
U.S. ENVIRONMENTAL PROTECTION AGENCY (continued)	
Environmental Research Laboratory, Ada, OK	950
Environmental Research Laboratory, Gulf Breeze, FL	1,464.8
Environmental Research Laboratory, Narragansett, RI	500
Risk Reduction Engineering Laboratory, Cincinnati, OH	1,622
Air and Energy Engineering Research Laboratory, Research Triangle Park, NC	3,645
Environmental Criteria & Assessment Office, Cincinnati, OH	1,500
Center for Environmental Research Information, Cincinnati, OH	600
Office of Research and Development, Washington, DC	150
U.S. ENVIRONMENTAL PROTECTION AGENCY TOTAL	**15,900**
TOTALS	
DoD LABORATORIES	52,747.5
DOE LABORATORIES	29,585
EPA LABORATORIES	15,900
LABORATORY TOTALS	**98,232.5**
OTHER FUNDING ITEMS	
Defense Agencies	16,700
Arctic Supercomputer	25,000
Supercomputing Support	3,000
DoD/EPA Manuals	250
OTHER FUNDING TOTAL	**44,950**
FY 1992 Scientific Advisory Board and Council Support	1,111.25
FY 1993 Scientific Advisory Board and Council Support	1,000
Expired	350
Undistributed	8.25
Undistributed Congressional Adjustments	3,188
TOTAL SERDP FUNDING	**148,840**

Section G. Description of any changes in military specifications recommended by the Council, actions to be taken to effectuate any such recommended changes on an expedited basis, and the projected date for each such change.

To date the Council has not recommended any changes in military specifications. No actions have been recommended to be taken to effect any changes in military specifications.

Section H. Description of all contracts, agreements, or other documents for cooperative research and development activities entered into pursuant to the Stevenson-Wydler Technology Innovation Act of 1980 during FY 1992.

Although there are no contracts nor cooperative research and development agreements (CRADAs) in effect as yet, there are a number of emerging technological developments that warrant pursuit under CRADAs in support of SERDP. Some examples follow:

As noted earlier, the participating agencies have jointly developed a cone penetrometer system equipped with chemical sensors, SCAPS, that can be used to monitor hazardous disposal areas. SCAPS is an automated system with a cone penetrometer equipped with sensors that can be used to detect and monitor subsurface soil and groundwater contaminated with fuels. This achievement is being augmented through the addition of advanced fluorescence spectroscopy for detection of solvents, explosives and metals contamination. The technology is well suited to licensing for widespread field use.

Currently, the Army has no proven treatment technology for the "red water" effluent resulting from TNT production. "Red water" is the chemically reactive waste product that occurs normally during the manufacture of TNT. Wet air oxidation is being pursued to provide a means of neutralizing this waste. The process is promising and should provide an opportunity for cooperative agreements under which process development could be accelerated and ultimately licensed for use in the private sector.

A hot gas decontamination process is being vigorously pursued by the Government as a means to cleanse materials and structures that are contaminated by chemical agents or explosives. A comparable problem is faced by the U.S. chemical industry in terms of contaminated processing equipment and underground piping. This provides a significant opportunity for a joint government/industry effort.

Section I. Plans for transferring technology and information to other governmental agencies and to nongovernmental organizations involved in environmental research and related matters.

As a part of the executive action plan mentioned in Section A of this report, each funded SERDP project will be required to submit a Project Execution Plan that specifies a technology transition/transfer plan in FY 1993 stating the specific products to be transferred, to whom and when. Each SERDP investigator will also be requested to report on technology transition/ transfer activities during the planned SERDP Program Reviews and in required periodic reports. Project proposals contained in the *Strategic Investment Plan I*, describe various technology transfer items in the **Benefits** and in the **Partners and Related Activities** sections.

Technology and information will be transferred to other government agencies and to nongovernmental organizations in the form of technical reports, journal articles, and conference proceedings. The material will include improved methodologies, standardized protocols, and improved environmental technology selection and design criteria. Existing governmental technology transfer systems (such as the Defense Technology Information Center) will be utilized initially. In time, should the amount of specialized environmental information available demand, additional information access mechanisms will be added.

For many years, DoD (Army, Navy and Air Force), DOE and EPA have had programs to transfer scientific and technical information to the private sector. More recently all these agencies have developed a number of cooperative efforts with the private sector under the Federal Technology Transfer Act of 1986 (FTTA) to speed up the utilization of environmental technology. Many of these technology transfer activities were described in **Section H**.

The EPA project, Develop and Demonstrate Effective Site Restoration, Pollution Prevention and Pollution Control Technologies Applicable to Defense-related Operations, (pp. 34-37 of *Strategic Investment Plan I*), will provide the opportunity for EPA, DoD and DOE to share expertise to resolve existing and future environmental problems at defense-related installations. Many of the long-standing problems at these installations can be resolved cost-effectively by adopting technology familiar to EPA and its research staff. The adaptation of existing technologies to specific defense-related applications will also save DoD and/or DOE engineers time and resources which would have otherwise been devoted to identifying and possibly demonstrating similar cleanup technologies. Emerging technologies and remediation approaches developed by EPA offer the potential of lower cost and/or higher cleanup effectiveness. Many of the results from this research could be utilized by the private sector to deal with similar problems.

Another EPA project, Research to Characterize Environmental and Health Problems Associated with Defense-Related Operations, (pp. 225-227 of *Strategic Investment Plan I*), will facilitate the sharing of data, methodologies and experience by EPA, DoD and DOE relevant to the successful design of safe, cost effective environmental management, pollution prevention and restoration strategies for defense-related operations, whether for continued facility operation, or

closure and return to commercial use. Substantial cost savings should be realized, since existing research programs of all participants will be leveraged and built upon. The potential to integrate and "standardize" sampling, measurement and assessment methodologies across agencies, particularly EPA, DoD and DOE, could materially accelerate progress toward cleanup and improved management of long standing problems.

In a novel technology development to use defense technology for environmental purposes, e~SCRUB - The Application of DNA Pulsed Power to Electron Scrubbing of Flue Gas to Remove Unwanted By-products, (pp. 51-53, TAB B of *Strategic Investment Plan II*), the Defense Nuclear Agency is involved in a collaborative effort with the Karlsruhe Nuclear Research Center. Together they are demonstrating the effectiveness of electron beam dry scrubbing (EBDS) for removal of air toxins and NO_x from incinerators and powerplants using high sulfur content coal. With EBDS, a critical national environmental goal mandated by the Clean Air Act can be met without a devastating economic impact on the coal industry and the users of high sulfur coal.

Section J. Description of plans to increase access by Federal government personnel, State and local government personnel, college and university personnel, industry personnel, and the general public to data, under the control of, or otherwise available to, the DoD, relevant to environmental matters.

In 1991 the FCCSET Committee on Earth and Environmental Sciences (CEES) requested and received concurrence on a Data Management Policy for Global Change. That policy was developed by an interagency group with DoD participation and full support of the Navy Representative to the SERDP Council. As discussed in **Section B**, the SERDP Global Change projects directly relate to the U.S. Global Change Research Program (USGCRP). Their data management policy will be consistent with that adopted for the USGCRP by the FCCSET/CEES Subcommittee on Global Change Research.

The FY 1992 SERDP proposal, Definition and Demonstration of Remote Sensing Capability to Contribute to Environmental Understanding and Support for Environmental Issues, (pp. 3-5 of *Strategic Investment Plan I*), addresses the issue of data access. This effort includes a survey of existing archives of classified data products and related database capabilities. The current archive and access procedures will be evaluated with respect to preserving the archive and allowing access by a wider community of users. In addition, alternatives to existing procedures and policies which provide enhanced services will be investigated and implemented, as appropriate.

It is anticipated that this effort will lead to cooperation among DoD, DOE, NOAA, USDA, USGS, EPA, and other Federal agencies. This effort should promote the establishment of a well-defined process for accessing data and services that will enhance the mission accomplishment of Federal agencies and improve the environmental data available to the research community.

This project is also supporting Defense Meteorological Satellite Program (DMSP) digital data archive development at the NOAA National Geophysics Data Center in Boulder, CO. The DMSP archive effort will process, archive, and make available to global change and environmental scientists all image and in site DMSP data recorded on 8 mm tapes. These data provide researchers with a unique opportunity to utilize DoD remote sensing technology to monitor the Earth's environment on a global scale during both daytime and nighttime conditions.

In response to a Congressional request to create a team of scientists to determine the applicability of classified systems and data to environmental science, an Environmental Task Force (ETF) was planned and is now funded by SERDP to review the environmental community's needs; past, present and near-term classified systems and data/archives; and current government efforts that apply classified data to environmental issues. The ETF scientists will recommend release of specific classified information of value to the environmental community, as well as follow-on research opportunities.

Within Conference Report 102-328, SERDP funding was specified to be made "available for the Consortium for International Earth Science Information Network (CIESIN) to jointly study and develop mechanisms for transferring unclassified and recently declassified information to other government agencies and to non government organizations involved in global environmental change research." The resulting effort is supporting the establishment and demonstration of an Arctic region data base, accessible or distributed to user sites, to investigate various oceanographic and climatic phenomena associated with global change. By using existing technology, and incorporating DoD, DOE and other Arctic data sets, data will be available for investigating: point-source pollution impacts to Arctic and temperate coastal regions; atmospheric phenomena associated with changes in the Arctic environment; and human-induced changes to the Arctic environment and its effects on indigenous species and the environment.

Section K. Additional recommendations or proposals, including proposals for legislation, relating to the Strategic Environmental Research and Development Program as the Council considers appropriate.

10 U.S.C. §2902(b)(1) mandates that the Assistant Secretary of Defense responsible for matters relating to production and logistics shall be a member of the SERDP Council. Due to organizational changes within the Office of the Secretary of Defense, that position no longer exists. Responsibilities of that office are now those of the Deputy Under Secretary of Defense for Environmental Security. It is recommended that the pertinent legislation be modified to reflect this organizational change.

Due to an increased emphasis on the development of renewable energy, it is recommended that the DOE Assistant Secretary for Energy Efficiency and Renewable Energy be granted non-voting membership on the SERDP Council.

Furthermore, the DOE, "Director" of Environmental Restoration and Waste Management title has been changed to "Assistant Secretary of Energy for Environmental Restoration and Waste Management." The SERDP Council Membership should reflect this title change.